Du Mont

Cathode-ray Oscillograph

TYPE 303

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OPERATING AND MAINTENANCE MANUAL

Allen B. Du Mont Laboratories, Inc.
Instrument Division
CLIFTON • • • NEW JERSEY

Obviously, the design of any scientific instrument results from a series of compromises which represent the designer's opinion of an ideal instrument consistent with contemporary engineering techniques and present-day production possibilities.

In developing this instrument, an attempt has been made to incorporate those characteristics which, we believe, will satisfy the greatest number of applications.

We feel, however, that the real test of any instrument is the opinion of the man who uses it. This day-to-day test of the instrument's advantages and limitations will prove, more than any other method, just what characteristics are desirable.

Because of the nature of the equipment manufactured by Allen B. Du Mont Laboratories, Inc., it is only by complete cooperation between the customer and our Engineering Department that satisfactory designs can be achieved. In a continuous attempt to increase the applicability of our equipment to the problems of the engineer, we sincerely request suggestions advising in what manner the design of this equipment may be further extended to include these problems.

OPERATING AND MAINTENANCE
MANUAL

DU MONT
TYPE 303
CATHODE-RAY OSCILLOGRAPH

ALLEN B. DU MONT LABORATORIES, INC.
INSTRUMENT DIVISION
1500 MAIN AVENUE, CLIFTON, N.J., U.S.A.

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FIGURE 1-1 **THE DU MONT TYPE 303 CATHODE-RAY OSCILLOGRAPH**

PREFACE

This manual is intended to aid in the proper operation and maintenance of the Du Mont Type 303 Cathode-ray Oscillograph.

While operation of this instrument is not difficult, some new and unconventional techniques are involved. It is important that even experienced operators of the oscillograph read this manual carefully, with special emphasis upon Section III, the description of operating procedures.

Section I of this manual contains an elementary, block-diagram analysis of the Type 303. For the inexperienced operator, this section offers background information essential to a proper understanding of the instrument and its functions. The experienced operator is also advised to read this section before considering the operating procedures.

Section II contains the instructions for installation.

Section III comprises a detailed analysis of the operating procedures for the Type 303. IT IS IMPORTANT THAT THIS SECTION BE THOROUGHLY READ IF OPTIMUM PERFORMANCE IS TO BE OBTAINED.

Section IV is an analysis of the electronic circuitry of the Type 303.

Section V contains the maintenance and servicing data. Sections IV and V, in conjunction with the schematic diagram, provide the information required for proper servicing of the instrument.

SECTION I
GENERAL DESCRIPTION

1. INTRODUCTION

The Du Mont Type 303 is a high-gain, wide-band cathode-ray oscillograph, capable not only of qualitative analysis but also of accurate quantitative measurement. Numerous auxiliary circuits have been incorporated in the Type 303 which enable this instrument to perform those functions which previously were performed by more costly and elaborate equipment.

Particular care was taken in the design of the vertical amplifier of the Type 303 to assure faithful reproduction of pulses and other signals containing high-frequency components. By conventional terminology, this amplifier would be specified as having a bandwidth of 10 megacycles, since at this frequency the amplifier response is 3 db below the mid-frequency value. However, in an oscillograph of this type, such a specification is misleading, since, owing to the slow fall of the frequency-response characteristic at the high-frequency end (See Figure 1-2), the amplifier is usable for sinusoids of frequencies as high as 20 megacycles or more. A more significant statement specifies the vertical amplifier as reproducing a pulse rise time of 0.01 microsecond or less as a rise time of not more than 0.033 microsecond. This excellent pulse response of the Type 303 is illustrated by the oscillogram in Figure 1-3. The duration of this input pulse is 0.25 microsecond with a rise time 0.01 microsecond. The interval indicated by B is a reproduced rise time of approximately 0.03 microsecond as calculated by the 0.1 microsecond interval between peaks of the 10 megacycle timing markers, E. Note the absence of overshoot at point C.

The output of the vertical amplifier of the Type 303 is sufficient to produce an equivalent of 4 inches of undistorted deflection with symmetrical signals, and 2 inches with unidirectional signals.

Many other features have been included in the Type 303 to facilitate the study of high-frequency phenomena. For example, in order to assure the display of the entire leading portion of the input signal, a signal delay line is built into the vertical amplifier. The effect of this delay line is shown by interval A in Figure 1-3. It should be noted that all specifications for bandwidth, sensitivity, and undistorted deflection for the amplifier take into account the performance of this signal delay line.

Consistent with the frequency response of the vertical amplifier is the range of sweep speeds selected for the Type 303. Sweeps, both driven and recurrent, are continuously variable in duration from 0.1 second to 2 microseconds, and sweeps may be expanded up to six times full-screen diameter, with no visible distortion, so long as the maximum sweep speed of 6 inches per microsecond is not exceeded. Sweeps may be expanded beyond this limit, but some distortion may be introduced. A rise time of 0.033 microsecond, displayed on the fastest sweep, and with maximum expansion, will occupy 0.3 inch horizontally on the screen, and thus may be readily observed or measured. The sweep circuits of the Type 303 have been carefully designed to be free of horizontal jitter, even when the sweep is triggered by random signals. Furthermore, the sweep may be syn-

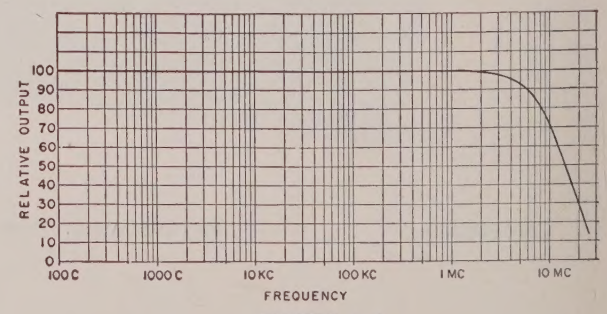


FIGURE 1-2
FREQUENCY-RESPONSE CURVE OF Y-AMPLIFIER

TABLE 1-1

PERFORMANCE SPECIFICATIONS

CATHODE-RAY TUBE

Type 5YP-

Accelerating Potential ..... E_{b2} + 1600 volts with respect to cathode. Intensifier + 3000 volts

Y-AXIS

Deflection Factor

Amplifier (at full gain) ..... 0.1 peak-to-peak volt/inch, or 0.035 rms volt/inch

Direct ..... 25 peak-to-peak volts/inch, or 9 rms volts/inch

Frequency Response

Pulse Response ..... 0.033 microsecond

Sinusoidal ..... Down not more than 30% from 10 cycles to 10 megacycles, with no positive slope above 10 kilocycles.

Undistorted Deflection

The cathode-ray tube used in this instrument has deflection-plate cut-off at 1.3 inches below and 1.3 inches above the center of the screen. But with the use of positioning, 4 inches of undistorted deflection may be obtained from a symmetrical signal. A unidirectional signal will give at least 2 inches of undistorted deflection.

Input

Maximum Allowable Input Potential ..... 600 volts d-c plus peak a-c.

Input Impedance

Direct

Amplifier ..... 2.0 megohms, 50 μμf

balanced ..... 7.8 megohms, 10 μμf

unbalanced ..... 2.0 megohms, 50 μμf

SIGNAL DELAY

A 0.25 microsecond delay of the Y-input signal allows the sweep to start before the amplified signal is applied to the deflection plates. Thus the full input signal may be examined without loss of its initial variation.

DU MONT TYPE 316 PROBE

The Type 316 probe may be used as an accessory with the Type 303. (The Type 316 Probe is not supplied with the Type 303). The probe (with 5 feet of cable) increases the input resistance to 4.7 megohms and decreases the input capacity to 15 μμf with an attenuation of 10:1. The small 3-12 μμf variable capacitor under the name-plate band is accessible for frequency compensating the probe. The capacitor should be adjusted so that a 10-kc square wave passing through the probe will show up as a perfectly flat-topped square wave.

VOLTAGE CALIBRATION

The unknown signal may be quantitatively examined by comparison with the standard voltages supplied to the input by a switch on the front panel. Square-wave signals of power line frequency which have peak-to-peak amplitudes of 0.1, 1, 10, and 100 volts, may be selected. The accuracy of these voltage standards is better than ±5%.

TIME CALIBRATION

An accurate determination of the sweep speed can be made by means of timing markers in the form of a damped oscillation applied to the Y input in place of the external Y-input signal. By means of a switch on the front panel frequencies of 10 kc, 100 kc, 1 megacycle, and 10 megacycles, may be selected. These frequencies correspond to 100 microseconds, 10 microseconds, 1 microsecond, and 0.1 microsecond time intervals. The accuracy of these frequency standards is better than ±3%.

X-AXIS

Deflection Factor

Amplifier (at full gain) ..... 0.35 peak-to-peak volt/inch, or 0.12 rms volt/inch

Frequency Response ..... Uniform within 30% to 500 kilocycles at high end; flat to d-c at low end.

Undistorted Deflection ..... 5 Inches

LINEAR TIME BASE

Sweep Circuit ..... High vacuum tube circuit, either triggered or recurrent.

Sweep Duration ..... Continuously variable from 0.1 second to 2 microseconds.

TABLE 1-1 — Cont'd

Expandable Sweep

The sweep of this instrument is expandable to an equivalent of six times the full-screen diameter of the cathode-ray tube with no on-screen distortion of the sweep; the positioning circuits are broad enough to examine any portion of the sweep on the screen without distortion. The expanded sweep is capable of a sweep writing rate of six inches per microsecond or faster.

Sweep Gating

A gate turns the beam on only during the left-to-right traverse of the spot; thus the return trace is not visible upon the screen. The spot is also invisible prior to triggering of a driven sweep.

INTENSITY-MODULATION CIRCUIT

Input Impedance	40,000 ohms, 80μμf
Sensitivity	15 positive volts peak will blank the beam.

TEST SIGNAL

The negative gate is brought out to a front panel terminal. It has an amplitude of approximately 75 volts with an internal impedance of less than 1000 ohms.

POWER SUPPLY

The equipment is capable of operating from a power line of 115/230 volts ±10%, 50-60 cycles. The d-c supplies are adequately filtered and regulated to prevent interaction between the various circuits when operated under normal conditions of line voltage and frequency.

TUBE COMPLEMENT

8 — 6AH6	2 — 6C4	2 — 2X2A	
1 — 12AU7	2 — 6AL5	2 — 5Y3	2 — 6AQ5
1 — 12AT7	3 — 6J6	1 — 5U4G	1—5YP-
2 — 6AU6	2 — 5763	1 — 5651	1 — VR75

PHYSICAL SPECIFICATIONS

Weight	75 lbs.
Width	12⅛"
Depth	19¾"
Height	16"

chronized by sinewaves of frequencies up to 20 megacycles or more.

Circuits are incorporated for the calibration of both time and voltage in the Type 303, making the instrument a precise quantitative measuring device. E and D of Figure 1-3 illustrate the capability of the Type 303 for time and amplitude calibrations.

In general, the excellent frequency response, sensitivity, and undistorted deflection, which make the Type 303 so well suited for electronic applications do not restrict this oscillograph from other research and industrial work, where the varying phenomena might require a transducer to translate non-electrical variations into electrical variations. For with the aid of such transducers as photocells, vibration and displacement pick-ups (to name but a few), the Type 303 can serve as a useful qualitative and quantitative indicating instrument in such fields as physics, chemistry, or mechanical engineering.

2. BASIC ELEMENTS

a. GENERAL.—The Type 303 consists of two essential components: the cathode-ray tube, and the electronic circuitry which provides the necessary operating conditions for the cathode-ray tube.

b. THE CATHODE-RAY TUBE.—The Type 5YP-Cathode-ray Tube, which is employed in the Type 303, embodies the latest development in cathode-ray-tube design. The vertical deflection plates are longer and are spaced more closely than is the practice in more conventional tubes. The result is a substantial improvement in deflection-plate

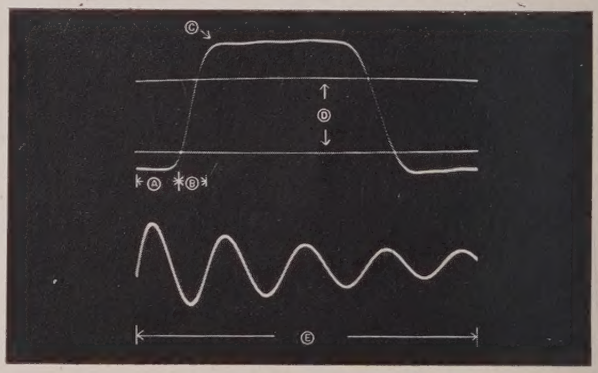


Figure 1-3: Pulse having a rise time of 0.01 μsec and a duration of 0.25 μsec as displayed on the Type 303. Timing markers (E) and Voltage-calibration lines (D) are also shown

sensitivity (approximately three times that of conventional cathode-ray tubes).

The useful vertical scan of the Type 5YP- is necessarily limited to 2.6 inches owing to this new deflection-plate structure which provides greater sensitivity. Nevertheless in the Type 303, the full range of the Y-Positioning control permits any expanded portion of a waveform to be brought onto the screen for close study. Figures 1-4, 1-5, and 1-6 illustrate this use of vertical, amplitude and positioning controls.

c. OSCILLOGRAPH CIRCUITRY.—To function as an indicator in an oscillograph, the cathode-ray tube must be provided with the potentials necessary to accelerate the electrons emitted by the cathode and to form these electrons into a beam of the smallest possible cross-section. Also the cathode-ray tube requires about 100 volts to give a full screen deflection of the beam; this necessitates horizontal and vertical deflection amplifiers if an oscillograph is to be a versatile indicating instrument. In addition to such amplifiers, the Type 303 has a self-contained linear time-base, or sweep generator and the required circuits to assure synchronization of the time base with the signal under study. Aside from the power supplies, deflection amplifiers, sweep generator, and synchronization circuits which are usually found in oscillographs, the Type 303 incorporates circuits which accurately calibrate the linear time bases as well as the amplitude of a signal applied through the vertical deflection channel.

3. FUNCTIONAL THEORY OF OPERATION

a. GENERAL.—The block diagram (Figure 1-7) illustrates the interrelation between the various stages of the Type 303. The power supplies have been omitted from this functional block diagram; the Type 303, however, has incorporated power supplies to satisfy all required potentials. Figure 3-1, the front panel of the Type 303, may be used to identify the front panel controls and input terminals which are indicated on the block diagram (Figure 1-7).

b. Y-AXIS (VERTICAL) DEFLECTION.—Normally input signals are applied to the vertical axis at the front panel binding posts, marked "Y Input." From the "Y Input" binding posts, the input signal is fed to the vertical attenuator through the "Calibrator" switch, a front panel control which passes either the signal ("Off" position), the time-calibration, or the voltage-calibration signal. The signal is applied to the Y axis input cathode follower through the "Y Attenuator," a front panel control. This "Y Attenuator" switch selects the desired amount of signal attenuation in seven steps: 1, 3, 10, 30, 100, 300, 1000. From the input cathode follower (V101), the signal is fed into the first stage of the vertical amplifier (V103) by means of the "Y Amplitude," a front panel control. The delay line, which is located between V103 and the remaining three stages of balanced amplification, delays the amplified signal for a period of 0.25 microsecond. When a signal is observed whose initial variation is used in starting the sweep, this delay line insures that this initial variation is displayed in its entirety, with no loss owing to the sweep-starting time. The final three stages of balanced amplification provide at the output of V108 and V109, two signals, which are identical but 180 degrees out of phase with one another. Thus, these two signals, when applied to the opposed vertical deflection plates, will augment one another's control of the electron beam.

When so desired, high level signals may be connected directly to the vertical deflection plates through terminal lugs at the side of the Type 303.

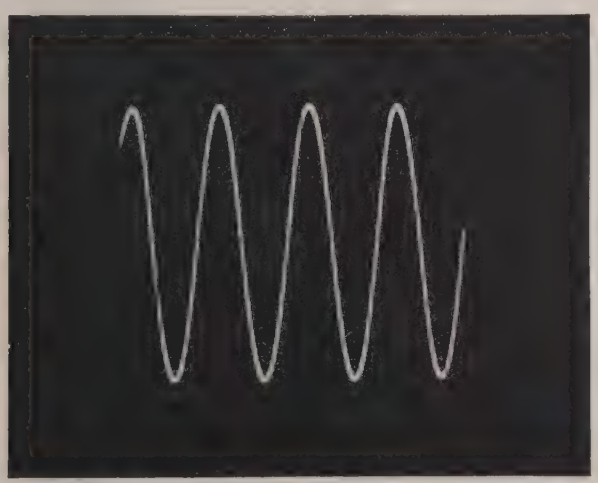


Figure 1-4: Sinewaves displayed over the entire useful vertical scan of the Type 5YP- Cathode-ray tube

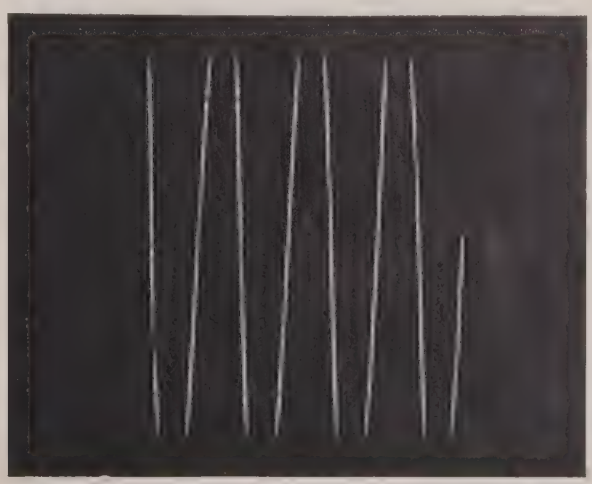


Figure 1-5: As vertical gain is increased, both positive and negative peaks are obscured, owing to the deflection-plate cutoff characteristic

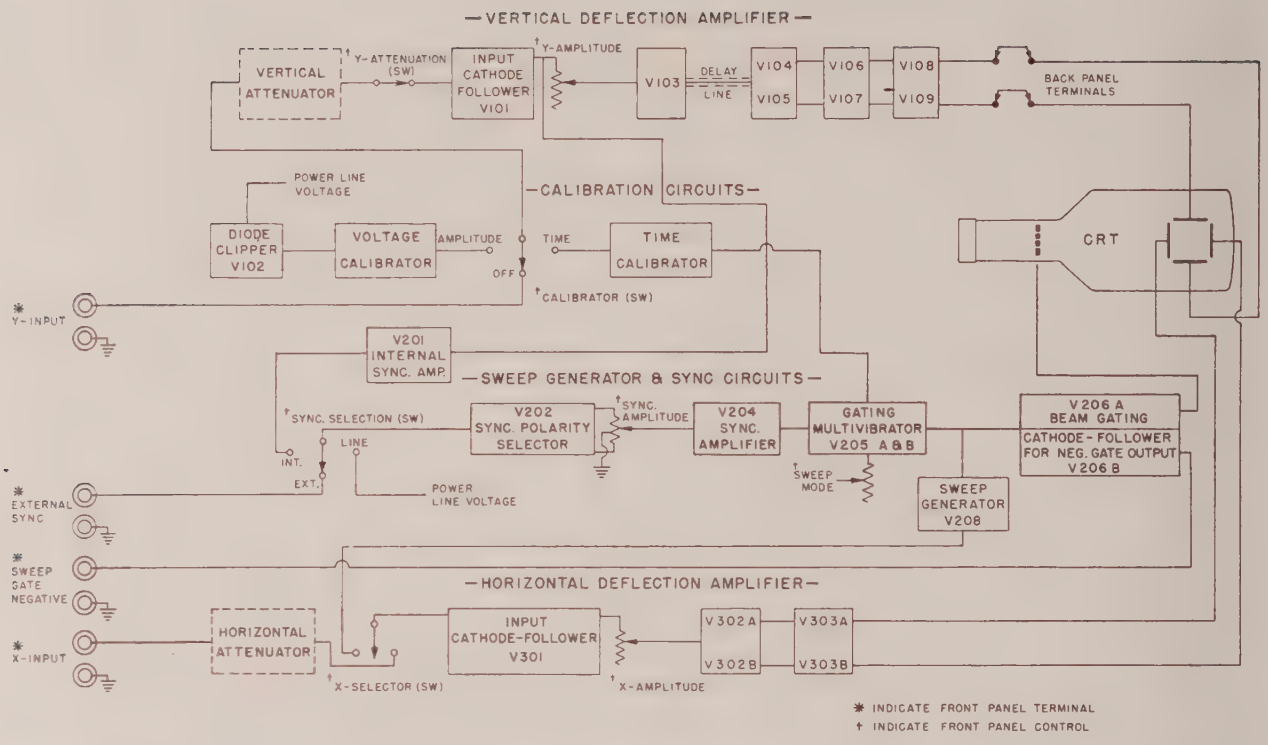


FIGURE 1-7 **BLOCK DIAGRAM OF THE TYPE 303**

c. AMPLITUDE CALIBRATION.—With the Type 303, accurate quantitative measurements may be made of the amplitude of the Y-input signal, or any portion of this signal, by use of the voltage-calibration circuits. For amplitude measurements the calibrating signal is substituted for the Y-input signal by means of the "Calibrator" switch, a front panel control. The calibrating voltage is obtained by accurately clipping (V102) and attenuating the 60-cycle line voltage to obtain square waves whose amplitudes on the cathode-ray tube screen correspond to voltage of 100 volts, 10 volts, 1 volt, and 0.1 volt. The calibrating square wave is applied to the vertical deflection plates through the same Y-axis channel as is the input signal; hence, the voltage relationship between the input signal and the calibrating square wave will always be a true one so long as the same setting of the "Y Attenuator" and the "Y Amplitude" controls are maintained during both the observation and voltage determination of the signal.

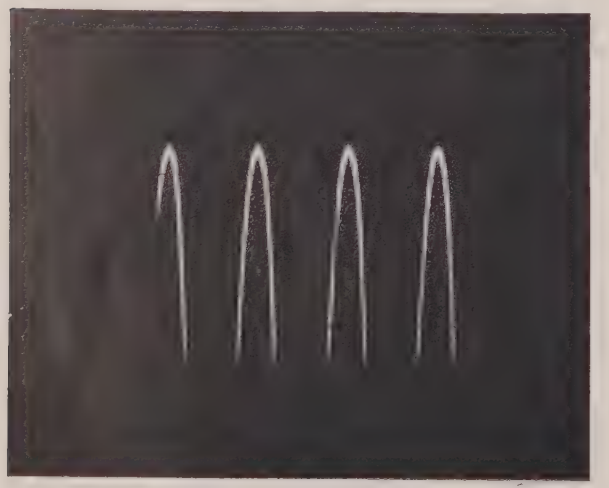


Figure 1-6: Peaks of sinewaves of Figure 1-5 may be examined by positioning pattern vertically until portion under study is brought onto the screen

d. SWEEP GENERATOR AND SYNC CIRCUITS.—The incorporated sweep generator of the Type 303 produces a linear time base which is continuously variable in duration from 0.1 second to 2 microseconds. In operation, this sweep generator moves the electron beam (and hence the fluorescent spot) across the screen of the cathode-ray tube at a constant rate from left to right. The spot then returns almost instantaneously to its starting position at the left side of the screen. The period of time which it requires the spot to transverse the screen is called the sweep duration or sweep time. In the Type 303, this linear time base

Figure 1-8: The output of Geiger-Mueller tube as displayed on the Type 303. Even when triggered by such random signals, sweeps of the Type 303 are free of horizontal jitter

is generated by charging and discharging a selected capacitor which is located between the plate of V208 and ground (see figure 1-7).

The output of this sweep generator (V208) is a sawtooth voltage wave, which when applied to the horizontal deflection plates of the cathode-ray tube through the horizontal deflection amplifier, provides sweep. The electronic stages which control both sweep frequency and the sweep duration of this linear time base are: the gating multivibrator (V205-A and V205-B) and its cathode follower (V206), the sync polarity selector (V202) and its amplifier (V204). The gating multivibrator (V205-A and V205-B) produces a negative gate which, when applied directly to the grid of the sweep generator (V208), stops V208 from conducting, thus allowing the sweep capacitor between the plate of V208 and ground to charge. This results in a linear movement of the spot from left to right on the screen of the cathode-ray tube. As the negative gate is removed, V208 conducts and the sweep capacitor discharges very rapidly. This represents the rapid and unseen return of the spot from right to left. The duration of the negative gate, and hence the sweep duration, is controlled by selection of the proper resistive and capacitive time constants in the grid circuit of V205-B. This selection is accomplished by "Multiplier B" and "Multiplier A," sweep-writing-rate controls. The recurrence of the negative gate (the gating multivibrator) is controlled by varying the grid bias of V205-A. This front panel control, "Sweep Mode," when set to the recurrent position allows the gating multivibrator to operate continuously. For "Recurrent" operation, the sweep frequency depends upon the repetition rate of the free-running multivibrator, which in turn depends upon the width of the square wave pulse as selected by the "sweep writing-rate" controls.

When the "Sweep Mode" is set at "Driven," the gating multivibrator requires a triggering voltage to start it, the sweep frequency depending upon frequency of the triggering voltage. In the driven position, the sweep frequency may be "locked in" from three synchronizing sources, an external signal, a sampling of the signal applied to the vertical axis, or a signal of power-line frequency. These three synchronizing sources may be selected by means of the front panel control, "Sync Selection." An external synchronizing voltage is applied at a front panel binding post; the internal synchronizing voltage (amplified by V201) is obtained from V101 in the vertical amplifier channel; and the synchronizing signal of power-line frequency is supplied from the power input. From the "Sync Selector" switch, the chosen synchronizing voltage is fed to the sync polarity selector (V202). This stage permits selection of either positive or negative synchronizing voltages. The chosen synchronizing voltage is then amplified by the Sync amplifier (V204) before being applied to trigger the gating multivibrator (V205-A and V205-B). The sync amplitude control permits adjustment of synchronizing voltages for stable sweep operation.

Figure 1-9: A vertical synchronizing and blanking pulse, from a television sync generator, displayed on the Type 303 with no expansion of sweep

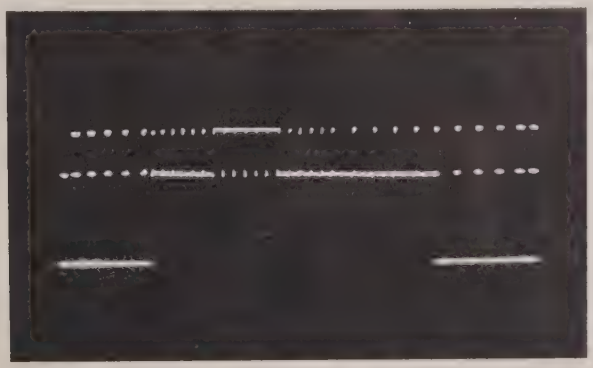


Figure 1-10: The same sync and blanking pulse as shown in Figure 1-9, displayed here on an expanded sweep.

When displaying a random phenomenon, such as the output of a Geiger-Mueller tube which is shown in the oscillogram of Figure 1-8, the very erratic triggering pulses might cause some sweep jitter. In such cases this jitter may be largely eliminated by the insertion of a IN34 crystal diode. The crystal diode when inserted across R301, at the output of V208, provides d-c restoration to eliminate horizontal jitter from random triggering. The IN34 crystal diode is not supplied, although a clipholder for it is located underneath the chassis, at the extreme front and right. To insert the diode, the instrument must be removed from its cabinet. Note that this diode is required only in extreme cases of erratic sweep triggering.

The cathode-ray tube is "on" only while the sawtooth sweep voltage moves the beam from left to right; the electron beam is extinguished at all other times. There are two advantages to such an arrangement.—(1) Since the beam is extinguished during the return time of the sweep, the return trace is not visible on the screen to confuse interpretation. —(2) It simplifies the recording of transient phenomena —the shutter of the oscillograph-record camera may be left open before and after the transient with no danger of fogging the film since there is no brilliant spot at the edge of the screen. Beam brightening is accomplished by applying a positive square wave, whose duration is the same as the negative gate (obtained from V206B sweep gate cathode follower), to the control grid of the cathode-ray tube to "turn on" the beam for the duration of the negative gate and hence the sweep duration. A negative square wave of sweep gate duration is provided at a front panel binding post ("Sweep Gate, Negative"), and may be used to initiate external equipment in synchronism with the sweep of the Type 303. This is a low impedance output supplied from V206A, sweep gate cathode follower.

e. TIME CALIBRATION.—Time calibration of the sweep is accomplished by substituting, for the Y-axis input signal, a damped oscillation of 10 kc, 100 kc, 1 mc, or 10 mc. These frequencies, which correspond to time intervals of 100 μsec, 10 μsec, 1 μsec, and 0.1 μsec, are obtained by shock excitation of tuned resonant circuits. Excitation for these circuits is accomplished by the negative sweep gate, which is generated by the gating multivibrator (V205-A and V205-B). When obtaining accurate time measurements, sweep controls should not be altered from the positions established for observing the signal, since this would obviously change the time base being calibrated.

f. X-AXIS (HORIZONTAL) DEFLECTION.—Deflection voltages are applied to the horizontal deflection plates through the horizontal deflection amplifier. The input to this amplifier channel (see figure 1-7, block diagram) may be taken from two sources, external or sweep (internal), depending upon the position of the front panel switch, "X Selector." When this switch is set upon the sweep position, the output of the internal sweep generator (from V208) is applied to the input cathode follower, V301, and, hence, to the horizontal-deflection plates through two stages of balanced amplification. Thus two amplified deflection voltages, which are identical but 180 degrees out of phase, are provided. These two outputs, when applied to the opposed horizontal-deflection plates, will augment one another's control of the electron beam.

The "X Amplitude" control, or "Multiplier C," varies the gain of the X-axis amplifier. As such, the "X Amplitude" control provides continuous control over the expansion of the sweep. The value of this sweep expansion (up to 6 times screen diameter without distortion) is illustrated by the oscillograms in figures 1-9 and 1-10.

Two external positions provide attenuations of 1:1 and 10:1 for application of an external signal to the X Axis. As can be seen from figure 1-7, the block diagram, an external signal for horizontal deflection, when connected to the front panel binding posts, may be first attenuated before being applied to the horizontal amplifier and deflection plates.

g. POWER SUPPLY.—The Type 303 has a self-contained power supply (not indicated on the block diagram) which furnishes all necessary currents and voltages for proper operation of the cathode-ray tube and auxiliary electronic circuitry. The front panel controls "Focus" and "Intensity" provide a fine adjustment for those power supply potentials applied respectively to the focusing anode and the cathode of the cathode-ray tube.

h. Z-AXIS (INTENSITY) MODULATION.—Provision is made in the Type 303 for modulating the intensity of trace on the cathode-ray tube screen. The front panel binding post "Z Input" is capacitively coupled to the cathode of the cathode-ray tube. When a positive pulse is applied to the cathode through this binding post, the trace will be blanked for the duration of the applied pulse. Positive pulses of approximately 15 peak volts will blank the beam from normal intensity settings.

SECTION II
INSTALLATION

1. INSTALLATION

In most instances, the Type 303 Cathode-ray Oscillograph is shipped with all tubes in place and ready for operation. However, the cathode-ray tube may be packed separately.

To install the cathode-ray tube, the chassis must be removed from the cabinet. Two screws near the bottom at the rear of the cabinet hold the chassis in place. Remove these two screws, and unwind the power cord from its bracket. The instrument will now slide forward out of the cabinet. The power cord and its plug will feed through the hole provided in the rear of the cabinet.

Remove the bezel and calibrated scale and insert the cathode-ray tube through the front panel and tube shield as far as the socket. A gentle push, with one hand on the face of the tube and the other hand supporting the tube base and socket, will seat the tube in the socket. Fasten the tube and base clamp. Next connect the intensifier lead (a heavy insulated high-voltage lead) to its contact which is located on the barrel of the cathode-ray tube. Then connect the second anode and deflection plate leads to their respective contacts located on the neck of the cathode-ray tube. These leads and the contacts on the neck of the tube are clearly indicated by marking tabs.

Next replace the calibrated scale. Plug in the power cord and turn the instrument on. Observe whether the horizontal trace is parallel to the horizontal lines of the calibrated scale.

THE INSTRUMENT SHOULD FIRST BE TURNED OFF BEFORE AN ATTEMPT IS MADE TO STRAIGHTEN THE CATHODE-RAY TUBE.

Before replacing the chassis in the cabinet, it is advisable to see that all tubes are properly seated in their sockets. All tube locations are clearly indicated on the chassis. Also, inspect the instrument for any mechanical damage which may have occurred in transit.

These operations completed, place the instrument back in its cabinet, and secure the screws.

2. PRECAUTIONS

a. MAGNETIC AND ELECTRIC FIELDS.—Magnetic and electrostatic shielding adequate for all ordinary applications has been provided in this instrument. However, operation of the instrument in strong fields (near transmitters, transformers, power generating equipment, etc.) may introduce spurious deflections.

Electrostatic pick-up may be minimized by the use of shielded input cables with connections that provide a good electrical ground on the chassis of the instrument. Spurious magnetic deflections may be eliminated or reduced to a degree that is unobjectionable by removing the instrument from the immediate vicinity of the disturbance; by orienting the instrument in the field so that spurious deflection is at a minimum; or, in extreme cases, by adding magnetic shielding in the form of a large iron or steel container in which the entire instrument may be placed.

b. POWER REGULATION.—The Type 303 is designed to operate at a power-line voltage of 115 or 230 volts rms (whichever is specified) at a frequency of 50 to 60 cycles per second. Steady variations of $\pm 10\%$ from the normal line voltage will cause little change in the operation of this instrument. Greater changes than this may cause the power supply, and thus the instrument, to operate erratically. Where power-line variations are excessive, constant-voltage transformers placed in the power line leading to the instrument are recommended. If such a regulator is used, the precautions outlined in the previous paragraph should be observed.

c. SCREEN BURNING.—When a small spot or line of high intensity is allowed to remain stationary on the screen of the cathode-ray tube, the entire energy of the beam is concentrated over a very small area, and the power input per unit of screen area is high. Under such conditions, the screen is susceptible to burning and discoloration. However, burning of the screen, until carried to excess, will not seriously impair the operation of the tube, since the burning is localized to small areas and the burned area is not completely insensitive.

WARNING

AVOID OPERATION OF THIS INSTRUMENT WITH THE CABINET REMOVED. DANGEROUS POTENTIALS AS HIGH AS 3000 VOLTS ARE EMPLOYED AND SHOULD BE TREATED WITH PROPER CAUTION.

SECTION III
OPERATING PROCEDURE

1. GENERAL

Operating procedure of the Type 303 is similar to the techniques established by past oscillographic equipment. There are, however, a few important and distinctive differences which must be thoroughly understood if the full capabilities of the Type 303 are to be realized. The operational theories involved in these new oscillographic techniques will be analized. The overall operating procedures are covered by Table 3-1, and the step-by-step instructions included in this section.

2. ENERGIZING THE TYPE 303

a. PREPARATION.—Step 1. Place the oscillograph on a level table or bench so the screen of the cathode-ray tube is in full view, and a minimum amount of light falls upon the face of the tube.

Step 2. Set the controls as follows:

Y Position	—center of range
X Position	—center of range
Intensity	—fully counter-clockwise
Power Switch	—down "Off"
Focus	—center of range
Y Attenuator Switch	—1000
Y Amplitude	—fully counter-clockwise
Calibrator	—"Off"
X Selector	—"Sweep"
Multiplier C or X Amplitude	—1
Multiplier B	—40
Multiplier A	—center of range
Sweep Mode	—center of range
Sync. Amplitude	—0
Sync. Selector Switch	—"Line"

Step 3. Plug the line cord into a power source.

b. OBTAINING THE TRACE.—Step 1. Turn the power switch to the "On" position.

Step 2. Allow 30 seconds for the instrument to warm up.

Step 3. Advance the "Intensity" control until a trace is visible on the cathode-ray tube screen. If only a spot is seen, rotate the "Sweep Mode" control clockwise until a trace appears.

WARNING

NEVER ADVANCE THE INTENSITY CONTROL TO A POSITION WHERE AN EXCESSIVELY BRIGHT SPOT APPEARS ON THE SCREEN. A VERY BRIGHT SPOT MAY BURN THE SCREEN AND DECREASE THE LIFE OF THE CATHODE-RAY TUBE. FOR THIS REASON A SHARPLY FOCUSED TRACE OR SPOT OF HIGH INTENSITY MUST NEVER BE PERMITTED TO REMAIN STATIONARY FOR ANY LENGTH OF TIME.

Step 4. Rotate the "Focus" control as required until the trace is clear and sharp (least "fuzzy"). The trace is then focused properly. Once in focus, either clockwise or counter-clockwise movement of the "Focus" control defocuses the trace. Having achieved a clear focus, the operator may decide that the trace is too bright. If such is the case, reduce the setting of the "Intensity" control and refocus.

The "Intensity" and "Focus" controls are inherently dependent on each other. Therefore, it is necessary, whenever one control is varied, to adjust the other control to obtain the best definition of the trace. When the "Intensity" control is turned too far clockwise, an extremely defocused trace is observed. The instrument should not be operated under these conditions.

c. POSITIONING THE TRACE.—Step 1. Adjust the "X Amplitude" control so that the trace is about one inch long.

Step 2. Rotate the "Y Position" control. Observe the movement of the trace. Adjust the "Y Position" control so that the trace is centered vertically.

Step 3. Rotate the "X Position" control. Observe the movement of the trace. Adjust the "X Position" control so that the trace is centered horizontally.

Step 4. The length of the trace may be adjusted to three or four inches by means of the "X Amplitude" control.

3. DISPLAYING SIGNAL ON RECURRENT SWEEP

Step 1. With the sweep upon the screen and the front panel controls set as indicated in Paragraph 2a, connect a repetitive signal to the "Y Input" terminals.

Step 2. Relocate the dividing line between "Driven" and "Recurrent" operation by turning the "Sweep Mode" control counter-clockwise from the "Recurrent" position until only a spot appears at the left of the screen. Move

the "Sweep Mode" control back towards "Recurrent" until the sweep reappears on the screen. Turn the "Sweep Mode" a bit further in the clockwise direction. The proper position for recurrent operation has now been selected.

Step 3. Turn the "Y Amplitude" control to 60. Reduce "Y Attenuation" until two of three inches of deflection appears on the screen. In most cases no recognizable signal will be present upon the screen, but only a great profusion of traces.

Step 4. Adjust "Multiplier B" to the approximate frequency of the signal, or until the profusion of traces reduces to a partially recognizable signal.

Step 5. Adjust "Multiplier A" until a definite waveform appears on the screen. The signal may be stopped from drifting by turning the "Sync Amplitude" control until the signal locks with no jitter. If desired, the "Sync Selector" may be switched from "Line" to "Internal" or "External." It must be remembered, however, that for given conditions of Y-Input signal, the polarity of applied synchronizing voltage is different for "Internal" as compared to "External." Proper instructions for the control of the "Sync Amplitude" are indicated in figure 3-2. If the input signal is a sinusoid, the "Sync Amplitude" may be turned in either direction, or in that direction which first locks the signal on the screen.

Step 6. If fewer cycles of the signal are desired, advance "Multiplier B" to the next position of increased writing rate. Readjust "Multiplier A," and relock the signal.

Step 7. If so desired, the displayed signal may be expanded for closer observation by advancing the "X-Amplitude" counter-clockwise. Expansion up to six times may be obtained without distortion.

Step 8. If the frequency of the input signal is very high (15 to 30 megacycles), the same procedure as above should be followed, although it may be necessary to advance the "Sweep Mode" further in a clockwise direction (toward "Recurrent"). Naturally, "Multipliers A & B" should be set to obtain the fastest sweep writing rate.

4. DISPLAYING SIGNAL ON DRIVEN SWEEP

Step 1. With the sweep upon the screen and the front panel controls set as indicated in Paragraph 2a, connect a non-recurrent signal to the "Y Input" terminals. To obtain a clearer understanding of operation of the Type 303 with a "Driven" sweep, it is suggested that a non-recurrent signal be chosen whose rate is slow. This might best be accomplished by manually triggering a pulse generator.

Step 2. Relocate the dividing line between "Driven" and "Recurrent" operation by adjusting the "Sweep Mode" control to the point where the recurrent sweep ceases. Turn the "Sweep Mode" a bit further counter-clockwise (toward the "Driven"). The "Sweep Mode" is now set for proper "Driven" operation.

Step 3. Turn the "Sync Selection" to "Internal" or to "External," if an external signal is to be used for synchronization. Depending upon the established conditions of the input signal and the method of triggering (Sync) selected, turn the "Sync Amplitude" control in the direction specified in Figure 3-2 until the sweep appears. If the signal is being triggered manually, it should be so triggered during the preceding operation.

Step 4. Turn the "Y Amplitude" clockwise to 60. Reduce the "Y Attenuator" until the signal appears upon the screen. The "Y Amplitude" may be adjusted to obtain a fine adjustment for the desired amount of vertical deflection.

Step 5. It may be desirable to display either more or less of a waveform upon the screen. To accomplish this, the "Sweep Writing Rate" controls, ("Multiplier A" and "Multiplier B") should be adjusted to give either a faster or slower writing rate. The "X Amplitude" control may be rotated counter-clockwise to provide even more horizontal expansion of the wave form.

5. SPECIAL CONSIDERATIONS

a. SWEEP WRITING RATE.—As can be observed from figure 3-1, the front panel of the Type 303, the sweep writing rate control, "Multiplier B," is calibrated in microseconds per inch with 7 fixed positions ranging from 0.3 microseconds to 4000 microseconds. This control establishes the seven different time durations of the square wave generated by the multivibrator as well as selecting the proper sawtooth time constant which corresponds to the chosen multivibrator pulse-width. "Multiplier A" will vary the pulse-width selected by "Multiplier B" in accordance with the multiplying factors indicated (1 to 5). Notice that these multiplying factors are not exact, and can only be used for an approximation of the sweep writing rate. "Multiplier C," the amplitude control in the X-Amplifier channel, varies the amplitude of the sawtooth voltage supplied from the sweep generator, V208 (see figure 1-7, the Type 303 block diagram). "Multiplier C" acts to expand or contract the sweep which has been established by "Multipliers A" and "B". The multiplying factors of "Multiplier C" upon the sweep writing rate are roughly as indicated. Since "Multiplier C" changes no constants in the multivibrator, it does not effect the sweep frequency.

b. SWEEP MODE CONTROL.—The function and operation of the "Sweep Mode" Control must be thoroughly understood for optimum performance. The "Sweep Mode" control, by establishing the grid bias of V205-A, determines when the multivibrator will fire. When this control is in a full counter-clockwise position, the multivibrator will not fire, and thus, no sweep is generated. As

TABLE 3-1

OPERATING CONTROLS AND TERMINALS

Name of Control	*Circuit Desig.*	*Component*	*Function*
Y POSITION	R174	100K Dual Potentiometer	Changes the Vertical Position of the trace.
X POSITION	R312	10K Potentiometer	Changes the Horizontal Position of the trace.
INTENSITY	R402	50K Potentiometer	Varies voltage between grid and cathode of the cathode-ray tube and, thus, the intensity of the trace.
FOCUS	R404	100K Potentiometer	Varies the voltage on the focusing electrode of the cathode-ray tube, and thus, adjusts the focal point of the beam.
Y ATTENUATOR	S101	4 Pole, 7 Position Switch	Selects attenuation ratio: 1:1, 3:1, 10:1, 30:1, 100:1, 300:1 or 1000:1.
Y AMPLITUDE	R120	500 ohm Potentiometer	Varies the amplitude of the vertical signal after passing through the input cathode follower, thus controlling the amplitude of vertical deflection.
X SELECTOR	S301	3 Pole, 3 Position Switch	Selects between internal or external signal for horizontal deflection. The internal signal is linear sweep. For external signals either 1:1 or 10:1 attenuation may be selected.
MULTIPLIER C *or* X AMPLITUDE	R308	10K Potentiometer	Varies amplitude of horizontal signal, after the signal has passed through the input cathode follower. Thus, it controls the amplitude of horizontal deflection. This control is calibrated so as to aid the operator in estimating the sweep writing rate.
MULTIPLIER B	S202	8 Pole, 7 Position Switch	Switches to various sweep capacitors to obtain step variations in sweep writing rate. The positions on this switch are marked so as to aid the operator in estimating the sweep writing rate.
MULTIPLIER A	R240	1-meg. dual Potentiometer	Provides a fine adjustment of the sweep frequency by controlling the rate at which the selected sweep capacitor is charged. This control is calibrated so that its reading multiplied by the readings of Multiplier B and Multiplier C gives the approximate sweep writing rate in microseconds per inch.
SYNC AMPLITUDE	R212	10K Potentiometer	Varies the amplitude of the synchronizing voltage applied to the time-base generator, thus enabling the operator to "lock-in" the signal being viewed, or to trigger off the driven sweep. This control facilitates the selection of signals of either negative or positive polarity.
SYNC SELECTOR	S201	2 Pole, 3 Position Switch	Provides means for selecting as a synchronizing signal, the vertical signal, a line-frequency signal, or an external signal.
SWEEP MODE	R233	200K Potentiometer	Adjusts bias on sweep multivibrator tube for either recurrent or driven sweep operation.
CALIBRATOR	S102	3 Pole, 9 Position Switch	Provides means of calibrating Y-input signal and sweep writing rate. For amplitude calibration four standard peak to peak voltages are provided: 0.1, 1, 10, and 100 volts. Four standard frequencies are provided: 10 kilocycles, 100 kilocycles, 1 megacycle, and 10 megacycles corresponding to 100, 10, 1, and 0.1 microseconds.
Y INPUT	J101	Binding Post	Provides a terminal for the connection of an external signal to the vertical amplifier.
X INPUT	J301	Binding Post	Provides a terminal for the connection of an external signal to the horizontal amplifier.
Z INPUT	J401	Binding Post	Provides a terminal for the connection of an external signal to the grid of the cathode-ray tube for the purpose of modulating the intensity of the trace.
EXT SYNC	J202	Binding Post	Provides a terminal for connecting an external synchronizing or triggering signal.
SWEEP GATE NEGATIVE	J204	Binding Post	Provides a terminal at which the negative gate of the sweep appears, as a square wave of approximately 75 volts.

FIGURE 3-1 FRONT PANEL OF THE TYPE 303

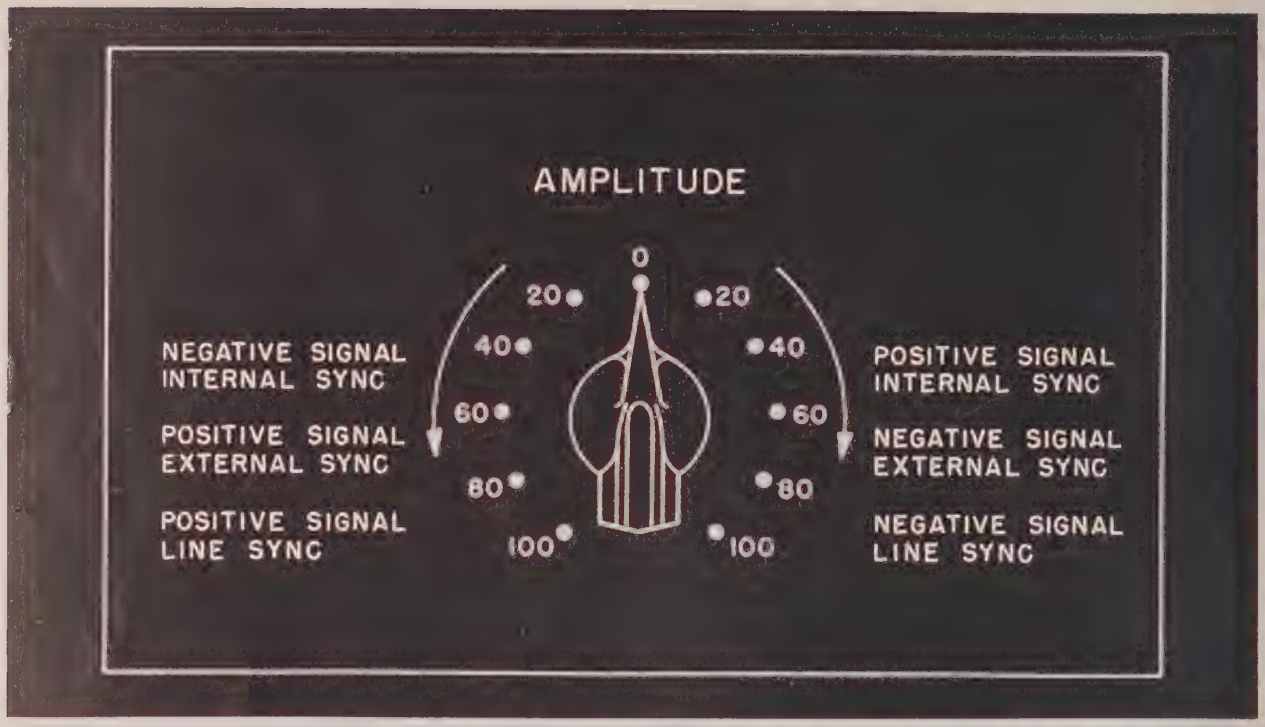


FIGURE 3-2 **SKETCH OF SWEEP SYNCHRONIZING CONTROL**

the "Sweep Mode" control advances clockwise, the grid bias on V205-A decreases to the point where V205-A conducts; the multivibrator fires producing the square-wave pulse, and hence the sweep. The point on the "Sweep Mode" control at which the multivibrator just becomes free-running (just above cutoff for V205-A) is the dividing line between "Driven" and "Recurrent" operation of the sweep. To obtain "Recurrent" operation, the "Sweep Mode" should be advanced just past this dividing line in a clockwise direction. To obtain correct "Driven" operation, the "Sweep Mode" control should be slightly backed off from this dividing line in the counter-clockwise direction. When setting the "Sweep Mode" control for "Recurrent" or "Driven" operation, always remember to keep the "Sync Amplitude" control set at zero.

c. SYNC AMPLITUDE.—The "Sync Amplitude" control adjusts the amplitude of the synchronizing pulses used to trigger the multivibrator (and hence the sweep) for "Driven" operation, or to "lock in" the free-running multivibrator for "Recurrent" operation. As mentioned before, it is of the utmost importance that the "Sync Amplitude" control be set at zero when setting the "Sweep Mode" control. The synchronizing pulses are applied to the grid of V205-A, the multivibrator tube whose bias is established by the "Sweep Mode" control. Thus, these synchronizing pulses also determine when V205-A will conduct to generate the square-wave pulse. For example, say that the "Sweep Mode" control was set so that V205-A were biased 6 volts below cutoff, and the amplitude of the synchronizing pulses were 8 volts. The multivibrator would then be fired by the 2 volts of the synchronizing pulses above cutoff. If the "Sweep Mode" control was set so that the grid bias of V205-A was 2 volts above cutoff, the multivibrator would become free-running; and any applied synchronizing pulses would lock in the multivibrator. In both "Driven" and "Recurrent" operations, however, the width of the square wave pulse is determined by the selected time-constants in the multivibrator circuits.

d. OBTAINING PROPER SYNCHRONIZATION POLARITY.—As can be observed from figure 3-1, the scale of the "Sync Amplitude" control is established with its zero amplitude position at the center top of the scale. Turning the control either to the right or left of center increases the amplitude of the synchronizing voltage. Proper synchronization is accomplished by turning the control in either direction, depending upon the polarity of input signal and whether internal or external synchronization is used. Figure 3-2 is a diagram which will establish these relationships. For example, with the given conditions of a negative signal employing internal synchronization, the "Sync Amplitude" control should be rotated in a counter-clockwise direction to apply the correct synchronization.

e. OBTAINING FULL ADVANTAGE OF SIGNAL DELAY.—Proper setting of the "Sweep Mode" and the

"Sync Amplitude" control is also important in maintaining the full advantage of the 0.25 microsecond delay of the Y-input signal. The delay insures a full display of signal by overcoming completely the sweep-starting time. For example, when internal synchronization is used for "Driven" operation, this delay line permits the sweep to begin a little less than 0.10 microsecond before the Y-input signal is applied to the vertical deflection plates. However, the full amount of this delay will be realized only when the "Sweep Mode" is set just slightly counter-clockwise from the dividing line between "Driven" and "Recurrent" operation, and just enough synchronizing voltage is applied to fire the multivibrator. If, by chance, the "Sweep Mode" control were set far below the true dividing line (so that the multivibrator were held in cutoff by a considerable voltage) and the amplitude of synchronizing pulses (taken from the Y-input signal) were set high enough by the Sync Amplitude control to fire the multivibrator, then the start of the sweep would be delayed from its true starting-time by the time it took the synchronizing pulse to rise to its voltage peak for the firing of the multivibrator. Thus, for the correct "Driven" operation, it is important that the "Sweep Mode" control be set as close to the dividing line as possible, without the sweep becoming "Recurrent," and the "Sync Amplitude" control set at zero. The "Sync Amplitude" control is then advanced just enough to insure the proper triggering of the sweep.

f. STABLE SWEEP.—To obtain stable sweep for recurrent operation, the "Sweep Mode" control should be advanced clockwise past the dividing line to the point where the sweep recurs regularly. Again, make sure that the "Sync Amplitude" is set at zero. Then, once the proper sweep writing rate has been chosen, the "Sync Amplitude" should be advanced to lock the signal.

6. CALIBRATION, VOLTAGE AND TIME

a. AMPLITUDE CALIBRATION.—Observe the voltage calibrator pattern by turning the "Calibrator" switch one position to the left of "Off." The pattern obtained is a square wave of 0.1 volt peak-to-peak which has been substituted at the input in place of the Y signal. At the other four Voltage Calibrator positions, signals of 0.1, 1, 10, and 100 volts peak-to-peak are available. A quantitative examination of the Y-input signal may be made by comparison with the known standard signals.

b. TIME CALIBRATION.—Observe the time calibrator pattern by turning the "Calibrator" switch two settings to the right of "Off." Set "Multiplier A" in the middle of its range and "Multiplier B" on 2. Set the "Sync Amplitude" at zero and the "Sweep Mode" for recurrent sweep. A damped oscillation is then obtained with one microsecond spacing between successive peaks. With "Multiplier C" ("X Amplitude") set at 1, adjust "Multiplier A" to produce 10 cycles for 1 inch. Count between the crests of successive peaks. A calibrated time base of 10 microseconds per inch has now been established, which can be used later for the quantitative time calibration of an unknown signal. It will be possible to alter the "Sweep Mode" control and the sync controls without altering the calibration of the sweep; PROVIDED THE SETTING OF "MULTIPLIERS A, B, AND C" ARE LEFT UNDISTURBED. Other rates of sweep writing speed can be calibrated in the same manner. The frequency standard selected by the "Calibrator" switch should provide a sufficient number of cycles, to give an accurate calibration of any given sweep writing rate.

7. MODULATING THE INTENSITY OF THE TRACE

Step 1. Obtain a repetitive trace with "Multiplier B" switch set at 0.3 and "Multiplier A" at about the center.

Step 2. Connect a short wire between the Z input and the Sweep Gate Negative signal and observe how the trace becomes brighter. Since the intensity modulation signal is applied to the cathode of the cathode-ray tube, a negative signal will brighten the trace.

WARNING

NEVER APPLY AN INTENSITY MODULATING SIGNAL LARGE ENOUGH TO SWING THE GRID OF THE CATHODE-RAY TUBE POSITIVE WITH RESPECT TO THE CATHODE. THIS UNWANTED, DANGEROUS CONDITION MAY CAUSE A SERIOUS REDUCTION IN THE LIFE OF THE CATHODE-RAY TUBE. AN INDICATION OF THE GRID SWINGING POSITIVE WITH RESPECT TO THE CATHODE IS MARKED DEFOCUSING ON THE SCREEN DURING THE POSITIVE PHASE OF THE INTENSITY MODULATING SIGNAL.

8. DIRECT DEFLECTION

It has already been pointed out that signals may be applied directly to the Y Deflection Plates through .047μf, 400-volt capacitors. Connections are made to binding posts on the side Terminal Board. Before any connections are made to the Terminal Board, the power should be turned off, since the terminals from the amplifier normally operate at about 300 volts above ground. To apply the signal, disconnect the jumpers between the amplifier and the deflection plates, and apply the signal to the two top terminals marked D3 and D4. This terminal board is located behind an access door in the left side of the instrument.

SECTION IV
CIRCUIT DESCRIPTION AND ANALYSIS

1. Y-AXIS DEFLECTION

a. GENERAL.—The signal may be applied to the vertical deflection plates either directly, or through a high-gain amplifier.

b. Y-AXIS AMPLIFIER.—For low-level signals, the Type 303 is provided with a high-gain, wide-band, amplifier (figure 4-1). The input system to the Y amplifier utilizes an attenuator which retains high-frequency characteristics. As can be seen from figure 4-1, the input attenuator is essentially of the decade type, using RC-compensated, stepped attenuators, and a linear gain control (R120).

The input cathode follower (V101) precedes the continuously-variable "Y-Amplitude" control (R120). The "Y-Amplitude" control has an attenuation ratio of more than 4:1 in its output. Resistor R121 has been put in series with the "Y-Amplitude" control (see figure 4-1) to prevent the operator from reducing the gain to zero. Thus any portion of the signal that saturates the input cathode follower will be deflected "off screen," and can be observed only after setting the input-attenuator switch in a position of greater attenuation.

The stage after the cathode follower is separated from the third stage of the Y amplifier by a signal delay line. This delay line delays the Y signal for 0.25 microseconds so that the leading edge of the input signal may be observed, despite the fact that the sweeps require a brief period to begin. The delay line used is the continuous type RG65/U cable which is terminated at both ends by networks made up of R126, R127, L106, and L107 at the input and R135, R136, L108 and L109 at the output.

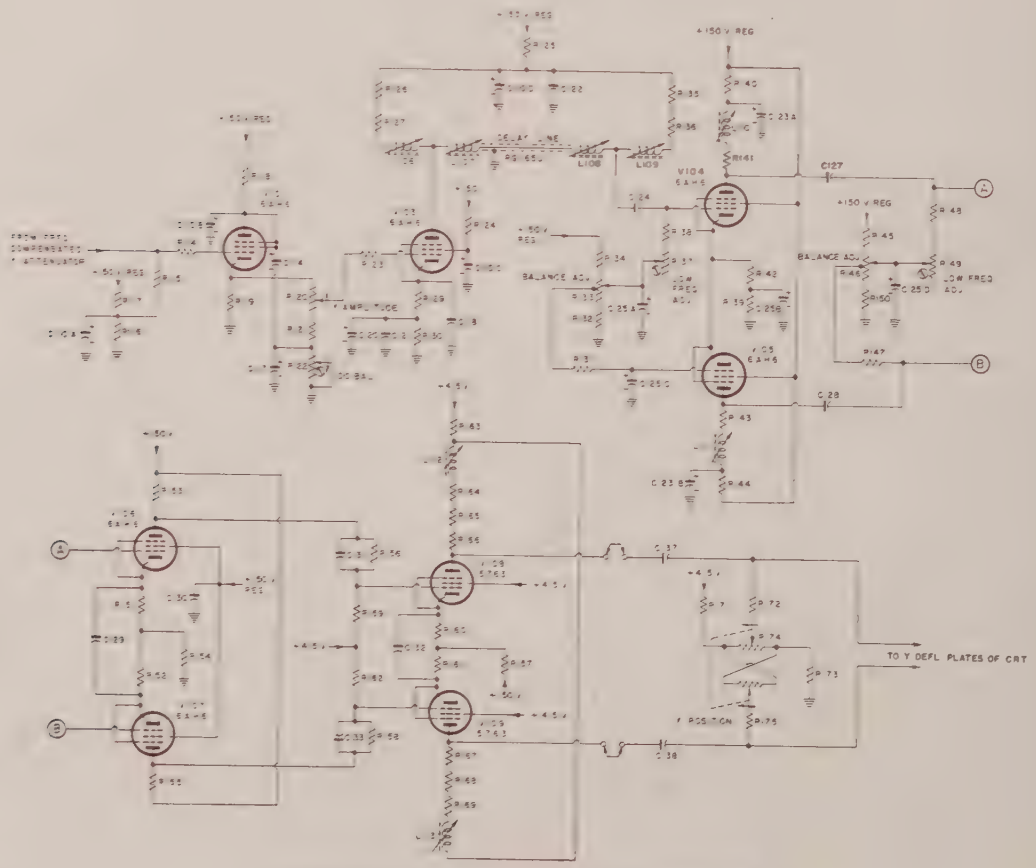


FIGURE 4-1 SCHEMATIC DIAGRAM OF Y-AXIS AMPLIFIER

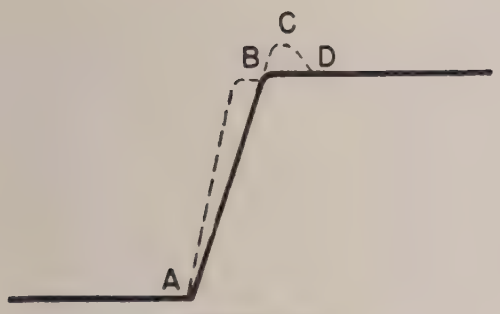


FIGURE 4-2
WAVE FORM ILLUSTRATING ADJUSTMENT OF PRE-EMPHASIS STAGE

The operation of the next stage, the pre-emphasis stage, can be best understood by referring to the diagram figure 4-2. Under normal conditions it would be expected that an excess of peaking inductance in the third stage would overpeak the amplifier along the dotted line BCD. But with this amplifier the plate load resistor of the third stage is very low (510 ohms), so that the overpeaking of this stage improves the rise time of the entire amplifier by causing it to rise along the dotted line AB.

The two halves of the balanced stage are equalized with potentiometer R133 in the third stage and potentiometer R146 in the fourth stage of the amplifier.

Part of the common cathode resistor of the third stage of the Y-Axis amplifier is by-passed with a capacitor, which compensates for certain distortions in the previous stages of the amplifier.

The second and third stages of the amplifier are compensated for low frequencies in the standard manner. Two of the grid resistors are made variable in order to take care of the large tolerances of the electrolytic condensers. The factory adjustments R137 and R149 are the variable parts of the grid resistors.

The stage before the output is d-c coupled to the output stage by means of the compensated attenuator system re-

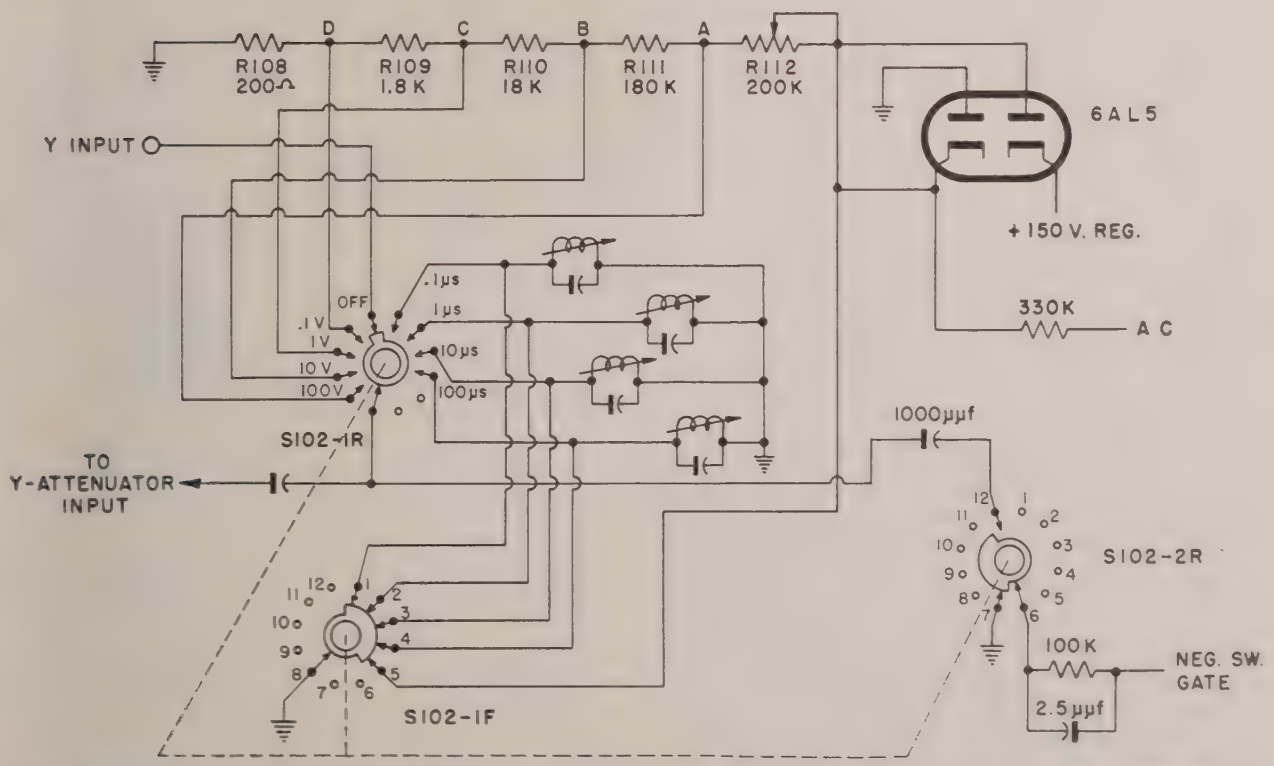


FIGURE 4-3 SIMPLIFIED SCHEMATIC DIAGRAM OF TIME AND VOLTAGE CALIBRATING CIRCUITS

turned to +415 volts. This raises the grid voltage of the last stage to about 9 volts above the cathode return of the last stage and hence makes it possible to use a common cathode resistor for the last stage. This tends to make the last stage independent of variations in tube characteristics.

The output stage of the Y amplifier is compensated for high frequencies by two shunt peaking coils, L112 and L113. Additional high-frequency compensation is supplied by the capacitor between the cathodes of the output stage. The same type of cathode compensation is provided in the next to the last stage. The peaking coils (L110 and L111) in the third stage of the amplifier are actually pre-emphasis coils. These coils compensate the stage for those higher frequencies dissipated in other parts of the amplifier, thus improving the high-frequency response of the Y-Axis amplifier.

c. Y-AXIS DIRECT INPUT.—Input may be connected directly to the Y-deflection plates through terminals and a series input capacitor of 400 volt rating. The terminals are available behind a door in the left side of the instrument. Only a-c input may be introduced since the deflection plates normally are about 280 volts above ground.

2. CALIBRATION

a. GENERAL.—This instrument is provided with voltage and time calibration. In both cases the Y-input signal is replaced by the calibrating signal (square waves of known voltage for voltage calibration and damped sinewaves of known frequency for time calibration). Figure 4-3 shows the composite voltage and time calibrator circuits. With the calibrator in the middle or "Off" position, the Y-input signal is applied to the Y amplifier. With the switch to the left, the voltage calibrator is connected to the Y input; and with the calibrator switch set to the right of the "Off" position the sinewaves of established frequency standards are connected to the Y input.

b. VOLTAGE CALIBRATION.—The voltage calibrator system starts with a line-frequency square wave which is produced by clipping an output from the secondary winding of the power transformer. The clipping levels are set between ground and +150 volts. By means of the 200 K potentiometer (R112) the square wave is adjusted for exactly 100 volts peak-to-peak at point A (see figure 4-3). This automatically gives peak-to-peak voltages of 10, 1, and 0.1 at points B, C, and D respectively. Therefore by throwing the calibrator switch to the first, second, third, and fourth position to the left of center, standard peak-to-peak voltages of 100, 10, 1 and 0.1 respectively may be applied to the Y-amplifier input in place of the normal input signal. It should be observed that the a-c signal is grounded in the "Off" position to prevent any cross coupling.

c. TIME CALIBRATION.—Time calibration is derived by shock-exciting resonant circuits with the Negative Sweep Gate. The following 4 parallel resonant circuits are provided: 10 kilocycles, 100 kilocycles, 1 megacycle, and 10 megacycles, which correspond to peak-to-peak intervals of 100 microseconds, 10 microseconds, 1 microsecond, and 0.1 microsecond. Observe that when the time calibrator is not used, the negative gate signal is shorted out. This avoids cross coupling into the Y-axis amplifier.

3. SYNC AND SWEEP GENERATOR CIRCUITS

a. GENERAL.—The sweep employed for the horizontal deflection of the Type 303 may be either the incorporated linear time-base, or any desired external time-base introduced through the front panel, "X Input" binding post.

b. LINEAR TIME BASE.—The sawtooth voltage necessary to obtain a proper sweep is generated by means of the electronic circuit shown in figure 4-4. The sweep is produced by the charging and discharging of the capacitor (C225 to C229) from the plate of V208 to ground. The capacitor is permitted to charge when a negative gate is applied to the grid of V208, cutting the tube off. When the negative signal is removed, the grid of V208 is restored to zero bias and the sweep capacitor discharges.

The sweep is linear since only about 10 per cent of the supplied voltage is used for the sweep. The sweep rate in microseconds per volt is determined by the time constant of the selected capacitor (C225 to C229) and the potentiometer (R240B), plus series resistor (R239). On passing through the X amplifier, the sweep appears on the screen as microseconds per inch, which is the product of the sweep rate (microseconds per volt) and the X-axis deflection sensitivity (volts per inch).

The gate at the grid of the sweep generator tube (V208) is produced by the multivibrator tube (V205). The duration of the negative gate, hence the sweep duration is determined by the time constant made up of the selected capacitor bringing signal to the grid of V205-B (C118 to C224) and the resistance in the potentiometer, (R240) and the series resistor (R242).

The negative gate appears at the grid of V205B and is directly coupled to the grid of the sweep generator tube (V208). The negative gate swings between ground and a negative voltage in the neighborhood of 50 volts.

The positive gate at the plate of V205B is fed to the grid of the cathode-follower (V206). The output of this stage is a positive gate, a-c coupled to the grid of the cathode-ray tube. The cathode-ray tube is thus turned on for only the time interval that the sweep is operating. The beam-gate is d-c restored at the grid of the cathode-ray tube so as to restore the grid to the same cutoff level when the sweep is

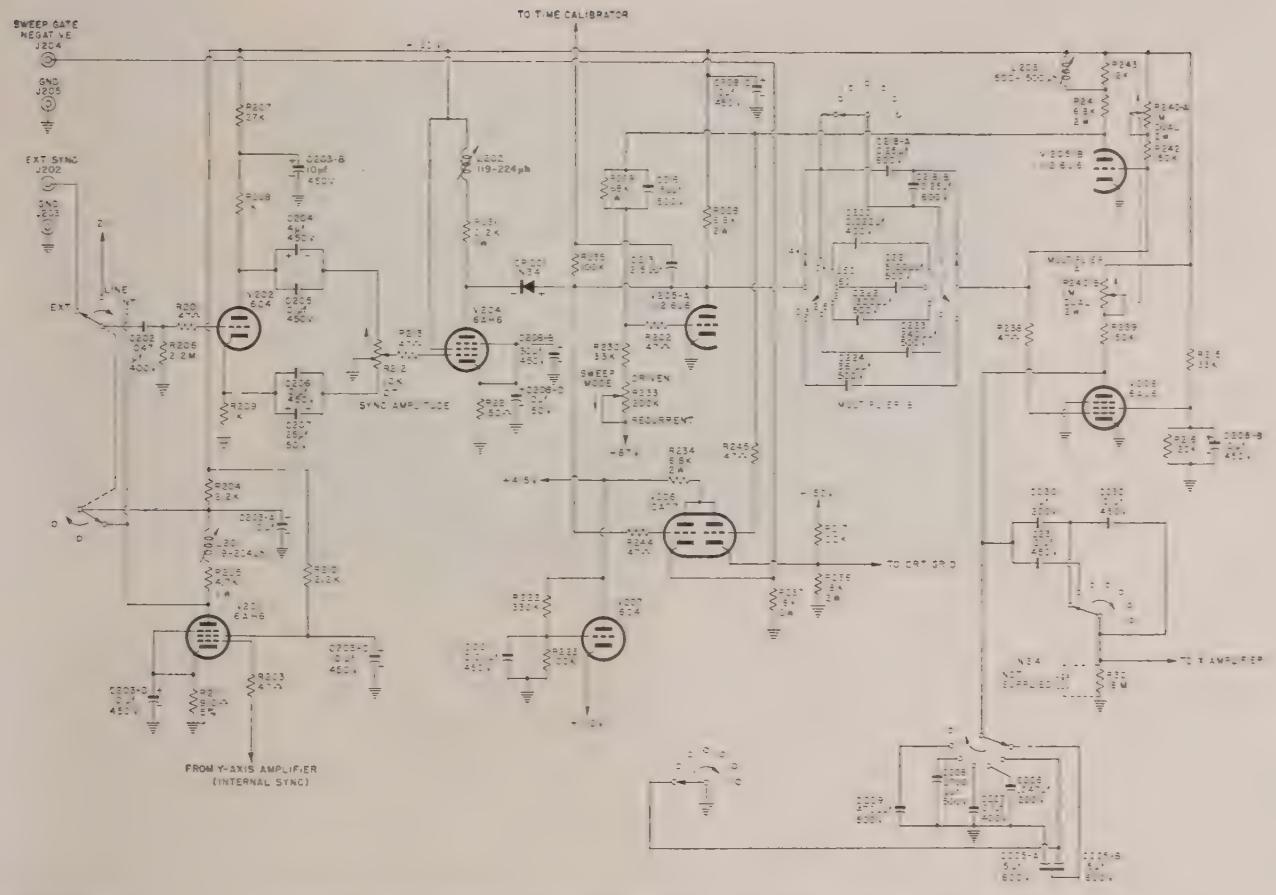


FIGURE 4-4 SCHEMATIC DIAGRAM OF SWEEP AND SYNCHRONIZING CIRCUITS

over (regardless of whether the sweep is recurrent or driven, low duty cycle or high).

The choice between driven and recurrent sweep is made by use of control R233, a 200 K potentiometer, which adjusts the bias on the grid of V205A. With the potentiometer resistance set at maximum, the multivibrator will operate recurrently. As the potentiometer resistance is reduced, the amount of negative bias on the grid of V205-A is increased, eventually reaching a point at which the gate can be started only if triggered. The trigger is supplied to the plate of V205A through a 1N34 diode from the plate of the sync amplifier tube (V204). Only a negative signal at the plate will couple through the 1N34 and trigger the sweep. After the sweep has started, the level of the plate of V205A will drop so low that no signal can couple to it through the 1N34, thus providing a sync lockout system. This sync lockout prevents a sweep from retriggering before it has completed a full sweep cycle as determined by the various time constants of the multivibrator. Thus, erratically occurring triggering pulses will not effect synchronization; and a common cause of horizontal sweep jitter is eliminated.

c. SYNC CIRCUITS.—The sync amplifier tube (V204) is preceded by a cathode-follower phase inverter stage with a potentiometer arranged so that the signal is zero at the center of the potentiometer. Equal amplitude but opposite polarity of synchronizing signal is obtained by rotating the potentiometer clockwise or counter-clockwise from the center position. This facilitates synchronizing or triggering the sweep multivibrator with either positive or negative input signals. The sweep multivibrator may be synchronized from three separate sources; the vertical amplifier or internal sync, an external source, or the 60-cycle power line. It should be noted that internal synchronization, which is taken from the cathode of V101 and fed through the internal synchronization amplifier (V201), will be 180 degrees out of phase with the input signal. This necessitates a different procedure for synchronizing internally as compared with externally. The correct procedure is clearly illustrated by figure 3-2.

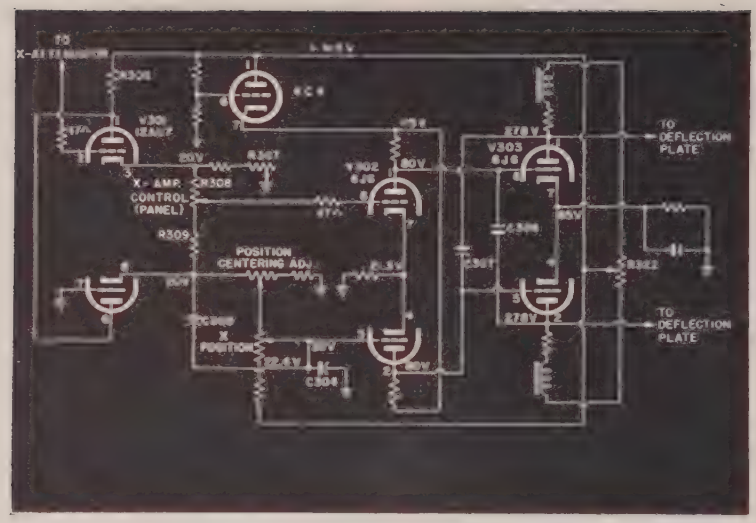


FIGURE 4-5 SCHEMATIC DIAGRAM OF X-AXIS AMPLIFIER

d. EXTERNAL SWEEP.—External voltage variations representing any desired time base may be applied to the horizontal deflection plates through the front-panel binding post, "X Input."

4. X-AXIS DEFLECTION

a. GENERAL.—For deflection along the X axis, either the internal sweep signal or an external signal may be used. The X amplifier is utilized in this instrument for both internal sweep and external signal. The X amplifier, completely d-c coupled, is seen in Figure 4-5.

b. X-AXIS AMPLIFIER.—The input cathode-follower (V301) precedes the continuously variable X-amplitude control (R308). The X-amplitude control has an attenuation ratio of more than 10:1 in its output. Resistor R309 has been put in series with the X-amplitude control (see figure 4-5). As with a Y-amplifier, this prevents the operator from cutting the gain down completely to zero; thus any portion of a signal that saturates the input cathode-follower will be deflected beyond full screen on the cathode-ray tube, and can be observed only after setting the input-attenuator switch in the 10:1 position. When using the internal sweep, this limiting resistor is switched out since the sweep voltage is not high enough to saturate the input cathode follower. Without this resistor it is possible to cut the sweep amplitude down almost to zero.

R307 is the d-c balance adjustment for the X amplifier. It equalizes the d-c voltage (with no input signal) at the two ends of the X-amplitude control, so that the gain can be varied without varying the d-c level.

The positioning voltage on the X amplifier is applied to grid of the first amplifier stage; the input signal is applied to the grid of the other half of this stage. The positioning potentiometer is returned to a point near the upper end of the cathode load of the cathode-follower. This tends to increase the amplifier stability, since variations in line voltage now produce about the same variations in voltage at the two grids of the first stage of amplification (V301).

A small portion of the input signal to V301 appears at the pin-8 cathode of V301. About 10% of the amplitude of the low-frequency components of the signal at the pin-8 cathode is lost through the divider network before it can reach the pin-5 grid of V302. To equalize the losses of high and low-frequency components, the capacitive divider, C303 and C304, has been added. To provide additional improvement, the two halves of the cathode-follower (V301) are supplied with a common plate resistor, R305. This resistor is of proper value to produce a signal at the cathode

(pin 8) which is almost equal in amplitude and opposite in phase to the signal which is already present at that point, thus resulting in cancellation. This assures better high-frequency response at the low end of the X-amplitude control, and it also facilitates reducing the sweep amplitude to less than 0.1 inch.

In the "Sweep" position resistor R309 is shorted out. If this were not done, a small portion of the sweep voltage would appear between the grids of the following stage, with the gain at minimum. Hence, too much residual deflection would be visible.

The horizontal d-c positioning system is such that even with six times full screen expansion, any portion of the pattern can be positioned on screen. Thus, as far as horizontal deflection is concerned, the Type 303 is the equivalent of an instrument having a 30-inch cathode-ray tube with a movable 5-inch mask that permits any portion of the trace to be examined.

The output stage of the horizontal amplifier is a twin triode. Good linearity is maintained in this output stage by the linearity adjustment potentiometer, R322. R322 arranges the relationship between the load resistors in the two halves of the output stage in such a way as to compensate for the variations between the two sections of the output tube.

The capacitors, C306 and C307, provide feedback to cancel out the input capacitance of V303, and hence improve the high-frequency response of the horizontal amplifier.

c. D-C AMPLIFICATION.—The X-axis amplifier of the Type 303 is direct-coupled throughout. As such, the amplifier can be used as a d-c amplifier. For completely independent operation the signal can be introduced through the front panel, "X Input." The amplified version may then be taken from the output of the final stage of the X amplifier.

5. POWER SUPPLY

a. GENERAL.—Figure 4-6 shows the power supply of the Type 303. The power supply is made up of four sections:

(1) A low-voltage positive supply of 150 volts at 170 ma. with the negative side grounded.

(2) A second low-voltage positive supply of 265 volts at 240 ma. with negative side connected to the high end of the +150 volt positive supply.

(3) A negative high-voltage supply of 1300 volts.

(4) A positive high-voltage supply of 1700 volts.

b. LOW-VOLTAGE POWER SUPPLY, +150 V.—This supply consists of a full-wave rectifier (V509). The output of this rectifier is filtered by a capacitor input filter consisting of C508, L501 and C507.

c. LOW-VOLTAGE POWER SUPPLY, +265 V.—This supply consists of a full-wave rectifier (V510 and V511). The output here is filtered by a capacitor input filter which consists of C510, L502 and C509. The low

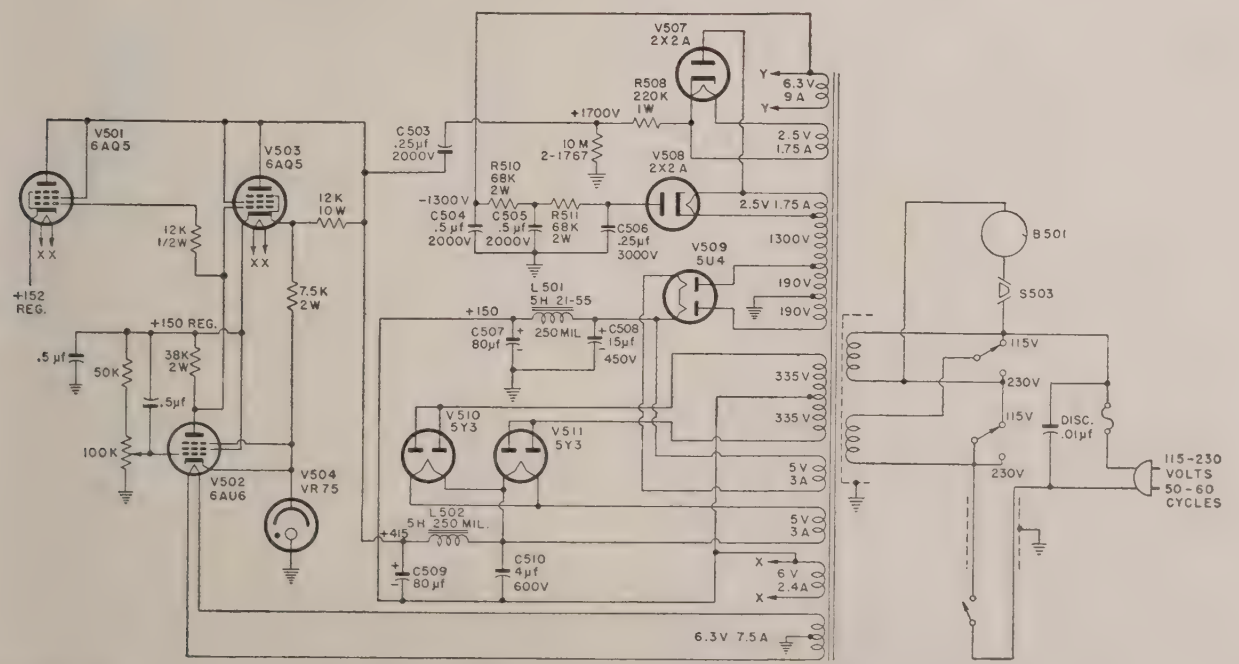


FIGURE 4-6 SCHEMATIC DIAGRAM OF POWER SUPPLIES

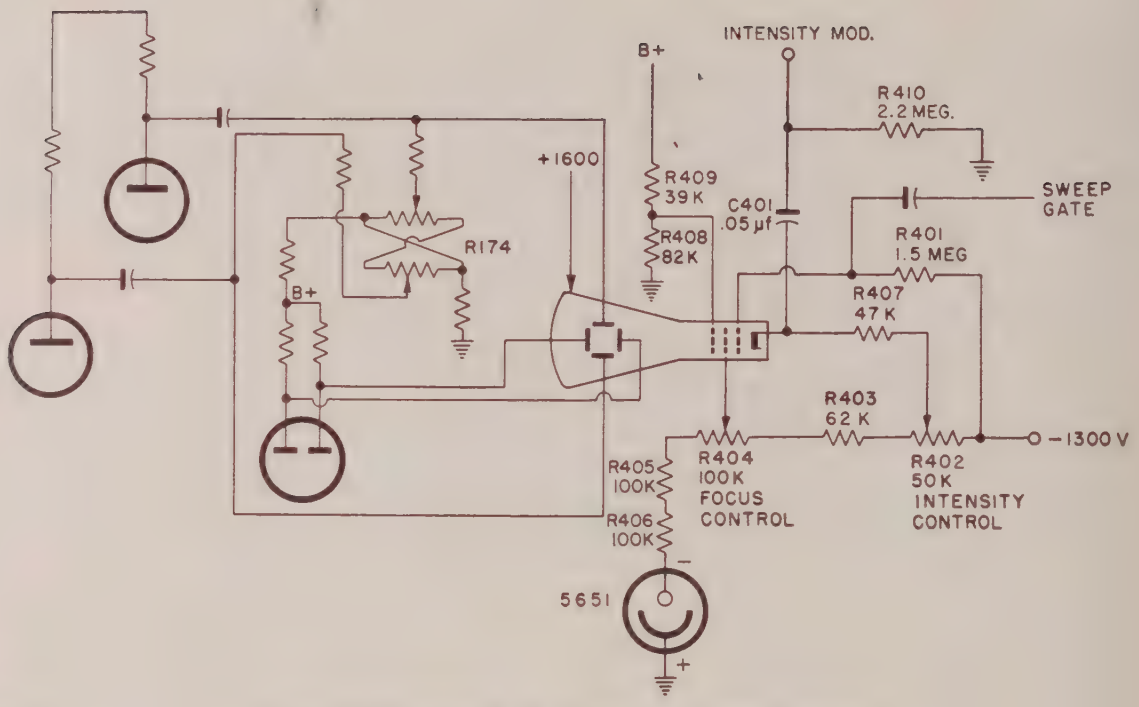


FIGURE 4-7 **SCHEMATIC DIAGRAM OF CATHODE-RAY TUBE CIRCUITS**

end of the +265-volt supply is connected to the high end of the +150-volt supply. This results in a supply of 415 volts. The 415-volt supply is used to produce two regulated potentials. A 150-volt, electronically-regulated supply is provided for operation of the Y amplifier and Voltage Calibrator sections. With the 150-volt regulated supply as a standard, a cathode-follower regulated supply (V501) is provided for operating the sweep section.

d. NEGATIVE HIGH-VOLTAGE POWER SUPPLY.—The negative high-voltage power supply employs a half-wave rectifier (V508). The output of this rectifier is filtered by a resistance-capacitance filter consisting of C506, R511, C505, R510, and C504. A voltage-divider network, attached to the output of this filter, determines the proper operating potentials for the various electrodes of the cathode-ray tube; see figure 4-7, schematic of cathode-ray tube circuits.

e. POSITIVE HIGH-VOLTAGE POWER SUPPLY.—Like the negative high-voltage power supply, the positive employs a half-wave rectifier (507). The output of this rectifier, is filtered by a resistance-capacitance filter consisting of R508 and C503.

f. VENTILATING BLOWER.—To insure an operating temperature, which will be considerably lower than the maximum specified for all components of the Type 303, a ventilating blower has been installed at the left rear of the chassis frame. The blower (B501) is energized in parallel with a 115-volt primary winding of the power transformer. This blower should be lubricated about every six months with light machine oil.

WARNING

OPERATION OF THIS EQUIPMENT INVOLVES THE USE OF HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OPERATING PERSONNEL SHOULD OBSERVE ALL SAFETY REGULATIONS. DO NOT CHANGE TUBES OR MAKE ADJUSTMENTS INSIDE THE EQUIPMENT WITH THE HIGH-VOLTAGE SUPPLY "ON." DO NOT DEPEND UPON THE POWER SWITCH FOR PROTECTION, BUT ALWAYS REMOVE THE POWER CORD FROM THE LINE OUTLET. UNDER CERTAIN CONTHE USE OF HIGH VOLTAGES WHICH ARE REMAIN IN THE CIRCUITS WITH POWER CONTROLS IN THE "OFF" POSITION DUE TO CHARGES RETAINED BY CAPACITORS. TO AVOID SHOCK AND SEVERE BURNS, ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM. NEVER SERVICE OR ADJUST THE INSTRUMENT WITHOUT THE PRESENCE OR ASSISTANCE OF ANOTHER PERSON CAPABLE OF RENDERING AID.

SECTION V

MAINTENANCE

1. GENERAL

The components used in the Type 303 Cathode-ray Oscillograph have been selected and tested to provide long, trouble-free operating life. It must be recognized, however, that trouble may be expected at some time during the life of the instrument. This section is included to provide useful information for the location and correction of such trouble.

2. DRAWINGS

The schematic of the circuit, located just inside the back cover, gives the complete information as to how the various components are connected. A list of parts with their descriptions is given on the reverse side of the page bearing the schematic diagram.

WARNING

DANGEROUS POTENTIALS AS HIGH AS 3000 VOLTS ARE FOUND IN THIS INSTRUMENT. SINCE THESE POTENTIALS MAY BE DANGEROUS TO HUMAN LIFE, THEY SHOULD BE TREATED WITH PROPER CAUTION.

3. CIRCUIT VOLTAGES

Table 5-2 is included to give voltages and resistances that are found between tube socket connections and ground. Unless otherwise specified, each measurement is made with a meter having an internal resistance of 20,000 ohms per volt. Naturally, voltage measurements taken with a meter having a lower internal resistance will differ from the values of this table.

It should be remembered that the values given are nominal and considerable variation may be experienced due to various line voltage conditions and component tolerences. Generally, a variation of ±10% is to be expected and 20% may not be uncommon. Judgment is often required to determine if a particular deviation is indicative of trouble.

4. FACTORY ADJUSTMENTS

a. GENERAL.—In order to avoid component pre-selection, a number of factory adjustments have been incorporated in this instrument. Some factory adjustments may need to be reset when replacing certain tubes. Table 5-1 lists the factory adjustments to be reset when changing tubes. Before making any adjustments, a 10-minute warm-up period should be allowed.

b. FOR Y-AMPLIFIER.—Factory Adjustments for Y Amplifier.

(1) Y-Amplitude Balance

FOR BETTER BALANCE - DISCONNECT THIS POT COMPLETELY

This potentiometer (R122) is located on the shock mounted chassis in the front-left side of the instrument. The adjustment is set for no vertical transient variations in the trace on the cathode-ray tube with rotation of the Y-Amplitude control with no signal input.

(2) Pre-emphasis Stage Balance

This potentiometer (R133), located in the lower right side of the long vertical chassis, equalizes the currents in the two tubes of the pre-emphasis stage. A 20,000 ohm per volt meter is connected between plates of V104 and V105, and the potentiometer R133 is adjusted so that no voltage appears between plates for no input signal.

(3) Driver Stage Balance

This adjustment (R146), located just above the Pre-emphasis Stage Balance, is performed similar to the Pre-emphasis Balance adjustment. The meter is connected between deflection plates of the output stage and the potentiometer is adjusted for zero reading on the meter.

(4) Pre-emphasis Stage Low-Frequency Compensation

This adjustment (R149), located to the right of the Driver Stage Balance, is made with the use of a 60-cycle square wave. The voltage calibrator square wave is quite satisfactory for the purpose. The decoupling resistor (R125) is shorted out and the .047 μf coupling capacitor (C124) is shorted by a larger capacitor of at least 1 μfd. The adjustment R149 is then set so as to produce a flat-top square wave. The shorts across the decoupling resistor and coupling condenser are then removed.

(5) Delay-Line Low Frequency Compensation

The same square wave pattern may be used for this adjustment (R137) located to the right of the Pre-emphasis Stage Balance. The adjustment is set to produce a flat-top square wave.

(6) Output Stage Peaking Coils

These peaking coils (L112 and 113) are located at the top of the long vertical chassis. A one-megacycle square wave should be applied to the input of the amplifier and these peaking coils adjusted first for a slight overpeaking, and then moved back just enough to eliminate the overpeaking.

(7) Pre-emphasis Coils

These peaking coils (L110 and L111) are located at about one-third of the way from the bottom of the long vertical chassis. These peaking coils are adjusted in exactly the same manner as the previous peaking coils.

FIGURE 5-1
WAVE FORMS ENCOUNTERED IN ADJUSTMENT OF Y-INPUT ATTENUATOR

(8) Delay Line Input Terminations

These peaking coils (L106 and L107) are located on the small vertical chassis. The coils are set with the aid of a one-megacycle square wave. This adjustment is made by sliding the two coils in the direction of increasing inductance until bumps are observed in the square wave pattern; and then sliding the coils back just enough to eliminate the bumps.

(9) Delay Line Output Terminations

These peaking coils (L108 and L109) are located at the bottom of the long vertical chassis and are set in exactly the same manner as the Delay Line Input Terminations.

(10) Y-Attenuator Compensating Capacitors

The trimmer capacitors, C103, C108, C102, and C104, located on the Y-Attenuator switch, are used for compensating the Y Attenuator in the 3:1, 10:1, 30:1, and 100:1 positions respectively. C139 and C140 are loops of wire acting as capacitors for compensating the 300:1 and 1000:1 positions. Compensation should be made by applying a 5-kc square wave to the "Y Input" and adjusting the capacitor corresponding to each position to pass the square wave without distortion, i.e. with a flat top.

In figure 5-1, above, A represents a proper adjustment and B and C represent conditions of overcompensation and undercompensation respectively for any of these capacitors.

c. FACTORY ADJUSTMENTS FOR X AMPLIFIER.—

(1) Linearity Adjustment

The X-Linearity Adjustment (R322) is located on the small horizontal plate in the rear-right side of the instrument. To set this adjustment use a sweep of one inch at about the mid-setting of Multipliers A and B. Position the pattern about 1½ inches to the left and 1½ inches to the right of center and observe whether the horizontal size of the pattern is greater at the left side or the right side of center. Then, by use of the X-Linearity adjustment, adjust the pattern to have the same amplitude on both sides of the center. This can be done by using the X-Linearity adjustment to position the pattern in the direction of reduced sensitivity.

(2) D-C Balance Adjustment

This adjustment (R307) is the front one of the two potentiometers on the X-amplifier bracket. The adjustment is made with the "X Selector" switch in one of the amplifier positions with the "X Input" grounded. The adjustment is set so that there is no change in X position with changes in X-amplitude setting.

(3) X-Position Centering Adjustment

This adjustment (R317) is just behind the D-C Balance Adjustment. This adjustment, too, is made with the "X Selector" switch in one of the amplifier positions with "X Input" grounded. The adjustment is set to center the spot horizontally on the Cathode-ray tube screen with "X Position" at mid-setting.

(4) Cross-Coupled Feedback Adjustments

These adjustments (C306 and C307) are feedback capacitors in the form of a few loops of wire located above the small chassis of the output stage. A 100-kc square wave applied to the "X Input" is used for making the adjustment. A sawtooth signal is applied to the Y axis and the square wave is adjusted to the point just before overpeaking is observed. The adjustment is made by winding or unwinding some loops.

(5) X-Attenuator Compensating Capacitor

The trimmer capacitor (C302) is used for compensating the X Attenuator in 10:1 attenuator position. This capacitor is located on the "X Selector" switch and is adjusted with a 5-kc square wave exactly in the same manner as are the Y-Attenuator Compensating Capacitors.

d. FACTORY ADJUSTMENT FOR SWEEP.—

(1) Beam Gate Adjustment

The peaking coil (L203) is used to adjust the high-frequency beam gate. The peaking is set to give as nearly as possible uniform brightness of the trace for the highest frequency sweep.

e. FACTORY ADJUSTMENT FOR POWER SUPPLY.—

(1) Regulated 150-volt Adjustment

This adjustment (R504) is located on the left side of the power supply chassis.

5. DU MONT "OSCILLOGRAPHER"

The Du Mont "Oscillographer," a quarterly publication, is published regularly by the Allen B. Du Mont Laboratories. It is sent free of charge to engineers, research workers, and those engaged in the use and application of cathode-ray equipment. When sending requests for subscriptions and address-change notice, please supply the following information: name, company name, company address, type of business, and title of individual.

6. DU MONT WARRANTY

All instruments produced by the Instrument Division of Allen B. Du Mont Laboratories, Inc., are sold under the Du Mont Warranty. For the provisions of this warranty, see the Warranty and Service Notice on the inside back cover.

7. SERVICE

The Instrument Division maintains complete facilities for servicing Du Mont equipment. For details of the Instrument Service policies, see the Warranty and Service Notice on the inside back cover.

TABLE 5-1

Tube No.	*Tube Type*	*Factory Adjustments*
V103	6AH6	Delay Line Input Terminations L106 and L107
V104	6AH6	Balance Adj. R133, Delay Line Output Terminations L103 and L109, Pre-emphasis Coils L110 and L111
V106	6AH6	Balance Adj. R146
V107	6AH6	Balance Adj. R146
V108	5763	Balance Adj. R146, Peaking Coils L112 and L113
V109	5763	Balance Adj. R146, Peaking Coils L112 and L113
V301	12AU7	D-C Balance Adj. R307, X Position Adj. R317
V302	6J6	X Position Adj. R317
V303	6J6	Linearity Adj. R322
V401	5YP	X Position Adj. R317
V502	6AU6	Regulator Adj. R504
V503	6AQ5	Regulator Adj. R504
V504	VR75	Regulator Adj. R504

TABLE 5-2

TABLE OF VOLTAGES AND RESISTANCES

(K = 1000 OHMS)

**Voltages are D-C; measured with a 20,000 ohm/volt meter, unless otherwise specified.*

Pin No.	*Res. to Gnd. (Ohms)*	*D-C Voltage to Gnd.*	*Control Affecting Reading*
	V-101 6AH6—Y AMPLIFIER INPUT		
1	2 Meg, 1 Meg, 220K, 78K, 32K, 18K and 14K	7.5 with VTVM	Y ATTENUATOR
2	31K	148	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	31K	148	
6	31K	148	
7	750	9.5	
	V-102 6AL5—CALIBRATOR DIODE		
1	30K		
2	0		
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	300K or 0	150V Sq. Wave or 0	CALIBRATOR SWITCH
6			
7	300K or 0	150V Sq. Wave or 0	CALIBRATOR SWITCH
	V-103 6AH6—Y AMPLIFIER DELAY LINE STAGE		
1	750-1250	9.5	Y AMPLITUDE
2	928	11.5	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	33K	110	
6	32K	144	
7	928	11.5	

TABLE 5-2 — Cont'd

Pin No.	*Res. to Gnd. (Ohms)*	*D-C Voltage to Gnd.*	*Control Affecting Reading*
	V-104 6AH6—Y AMPLIFIER PRE-EMPHASIS		
1	60-560K	4.7 with VTVM	R137, LOW FREQ. COMPENSATION
2	150	6.5	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	34K	107	
6	30K	150	
7	150	6.5	
	V-105 6AH6—Y AMPLIFIER PRE-EMPHASIS		
1	100K	4.7 with VTVM	
2	150	6.5	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	34K	107	
6	30K	150	
7	150	6.5	
	V-106 6AH6—Y AMPLIFIER DRIVER		
1	130K-530K	23 with VTVM	R149, LOW FREQ. COMPENSATION
2	1000	25	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	150K	142	
6	30K	150	
7	1000	25	
	V-107 6AH6—Y AMPLIFIER DRIVER		
1	195K	23 with VTVM	
2	1000	25	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	150K	142	
6	30K	150	
7	1000	25	
	V-108 5763—Y AMPLIFIER OUTPUT STAGE		
1	30K	302	
2			
3	150K	165	
4	150K	150	
5	150K	150	
6	30K	415	
7	150K	165	
8	150K	159	
9	150K	159	

TABLE 5-2 — Cont'd

Pin No.	*Res. to Gnd. (Ohms)*	*D-C Voltage to Gnd.*	*Control Affecting Reading*
	V-109 5763—Y AMPLIFIER OUTPUT STAGE		
1	30K	302	
2			
3	150K	165	
4	150K	150	
5	150K	150	
6	30K	415	
7	150K	165	
8	150K	159	
9	150K	159	
	V-201 6AH6—INT. SYNC. AMPLIFIER		
1	750	9.5	
2	910	11.5	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	150K	145	
6	150K	147	
7	910	11.5	
	V-202 6C4—SYNC. PHASE INVERTER		
1	175K	90	
2			
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	175K	90	
6	22 Meg	0	
7	1K	2.25	
	V-204 6AH6—SYNC. AMPLIFIER		
1	47 ohm—5K	0	SYNC AMPLITUDE
2	150	2	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	160K	130	SWEEP MODE
6	150K	152	
7	150	2	
	V-205 6J6—SWEEP MULTIVIBRATOR		
1	160K	80—140	SWEEP MODE
2	160K	70—135	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	150K—1 Meg.	25—0	SWEEP MODE
6	180K	1.75 to −40	SWEEP MODE
7	0	0	
	V-206 12AT7—GATE CATHODE FOLLOWERS		
1	30K	350	
2	160K	80—140	SWEEP MODE
3	18K	85—145	SWEEP MODE
4	Negligible	3.15 RMS (AC)	
5	Negligible	3.15 RMS (AC)	
6	30K	350	
7	160K	70—135	SWEEP MODE
8	18K		SWEEP MODE
9	Negligible	3.15 RMS (AC)	

TABLE 5-2 — Cont'd

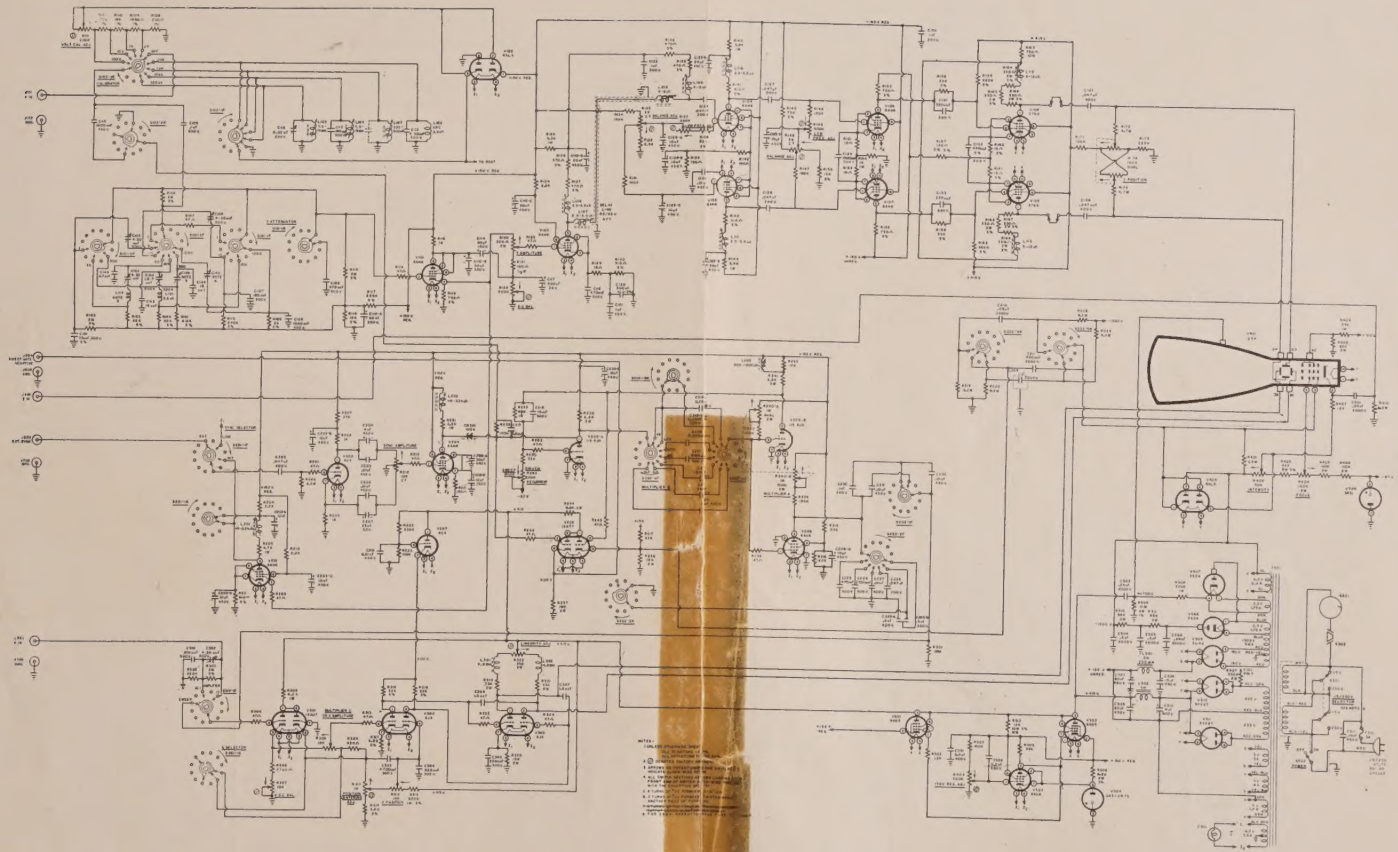
Pin No.	Res. to Gnd. (Ohms)	D-C Voltage to Gnd.	Control Affecting Reading
		V-207 6C4—REGULATOR	
1	30K	415	
2			
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5			
6	75K	96	
7	Infinite	110	
		V-208 6AU6—SWEEP SWITCH TUBE	
1	150—1 Meg	−25—0	SWEEP MODE
2	0	0	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	.3—1.3 Meg	0—15	SWEEP MODE, MULTIPLIER A
6	250K	100—40	SWEEP MODE
7	0	0	
		V-301 12AU7—X AMPLIFIER INPUT	
1	45K	340	
2	4.7 Meg—2 Meg—220K	0	X SELECTOR
3	8K	20	
4	Negligible	3.15 RMS (AC)	
5	Negligible	3.15 RMS (AC)	
6	45K	340	
7	0	0	
8	7K	20	
9	Negligible	3.15 RMS (AC)	
		V-302 6J6—X AMPLIFIER DRIVER STAGE	
1	Infinite	80	
2	Infinite	80	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	6K—16K	17.5—22.5	X POSITION
6	8K	20	
7	6.8K	21.3	
		V-303 6J6—X AMPLIFIER OUTPUT STAGE	
1	80K	120—400	X POSITION
2	80K	120—400	X POSITION
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	Infinite	80	
6	Infinite	80	
7	15,000	85	

TABLE 5-2 — Cont'd

Pin No.	*Res. to Gnd. (Ohms)*	*D-C Voltage to Gnd.*	*Control Affecting Reading*
		V-401 5YP—CRT	
1	600K	−1300	
2	650K	−1300 to −1150	INTENSITY
3	2 Meg	−1300	
4			
5	400K—500K	−700 to −1000	FOCUS
6			
7			
8			
9			
10			
11			
12			
13			
14	600K	−1300	
A2	40K	280	
D1	80K	120—400	X POSITION
D2	80K	120—400	X POSITION
D3	4 Meg	250—300	Y POSITION
D4	4 Meg	250—300	Y POSITION
		V-501 6AQ5—152 V REGULATOR	
1	40K	140	
2	150K	152	
3	150K	150	
4	150K	150	
5	30K	415	
6	30K	415	
7	40K	140	
		V-502 6AU6—SHUNT REGULATOR	
1	75K	73	
2	40K	75	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	60K	142	
6	30K	150	
7	40K	75	
		V-503 6AQ5—SERIES REGULATOR	
1	60K	142	
2	30K	150	
3	Negligible	3.15 RMS (AC)	
4	Negligible	3.15 RMS (AC)	
5	30K	415	
6	30K	415	
7	60K	142	
		V-504 VR75—REGULATOR REFERENCE	
1			
2	0	0	
3			
4			
5	40K	75	
6			
7			

TABLE 5-2 — Cont'd

Pin No.	*Res. to Gnd. (Ohms)*	*D-C Voltage to Gnd.*	*Control Affecting Reading*
	V-505 6AL5—BEAM GATE DC RESTORER		
1	2 Meg	−1300	
2	600K	−1300	
3	600K	−1300	
4	600K	−1300	
5	2 Meg	−1300	
6			
7	600K	−1300	
	V-506 5651—NEGATIVE REGULATOR		
1	0	0	
2	250K	87	
3			
4	250K	87	
5	0	0	
6			
7	250K	87	
	V-507 2X2A — +1700V RECTIFIER		
1	11 Meg	1900	
2			
3			
4	11 Meg	1900	
Cap	2000	1500 RMS (AC)	
	V-508 2X2A — −1300V RECTIFIER		
1	2000	1500 RMS (AC)	
2			
3			
4	2000	1500 RMS (AC)	
Cap	750K	1700	
	V-509 5U4G—150 V RECTIFIER		
1			
2	250K	165	
3			
4	25	190V RMS (AC)	
5			
6	25	190V RMS (AC)	
7			
8	250K	165	
	V-510 and V-511 5Y3GT—265 V RECTIFIER		
1			
2	30K	435	
3			
4	250K	150DC, 312 RMS	
5			
6	250K	150DC, 312 RMS	
7			
8	30K	435	



SCHEMATIC DIAGRAM OF THE DU MONT TYPE 303
CATHODE-RAY OSCILLOGRAPH
98000371-4 Issue 8

Component Parts List

Type 303 Cathode-ray Oscillograph

CAPACITORS

Symbol	Part No.	Description
C101	03020370	33 µµf 500 Volt ± 10% Mica
C102	03003070/3-307	4-30 µµf 500 Volt Var Ceramic
C103	Same as C102	
C104	03007790/3-779	1.5-7 µµf 500 Volt Var Ceramic
C105	03100490	0.001 µf 450 Volt Ceramic
C106	03020510	470 µµf 500 Volt ± 10% Mica
C107	03020460	180 µµf 500 Volt ± 10% Mica
C108	Same as C102	
C109	03011540/3-1154	0.1 µf 600 Volt Paper
C110	03014240/3-1424	2 x 20 2 x 30 µf Elect
C112	Same as C102	
C113	Same as C107	
C114	03015380	80 µf 150 Volt Elect
C115	Same as C105	
C116	03012340/3-1234	0.02 µf 200 Volt ± 20% Paper
C117	03013030/3-1303	500 µf 25 Volt Elect
C118	Same as C106	
C120	Same as C117	
C121	03015340/3-1534	1 µf 200 Volt Paper
C122	Same as C121	
C123	03017490	2 x 20 µf 450 Volt Elect
C124	03019580	0.047 µf 200 Volt ± 10% Paper
C125	03002350/3-235	4 x 10 µf Elect
C126	03019650	10,000 µµf 450 Volt Ceramic
C127	Same as C124	
C128	Same as C124	
C129	03029460	1500 µµf 500 Volt ± 10% Mica
C130	Same as C121	
C131	03021090	330 µµf 500 Volt ± 5% Mica
C132	03021120	430 µµf 500 Volt ± 5% Mica
C133	Same as C131	
C137	03019120	0.047 µf 400 Volt ±20% Paper
C138	Same as C137	
C142	03020330	15 µµf 500 Volt ± 10% Mica
C143	03014560	4.7 µµf 500 Volt±20% Ceramic
C144	03020340	18 µµf 500 Volt ± 10% Mica
C201	Same as C126	
C202	Same as C137	
C203	Same as C125	
C204	03000220/3-22	4 µf 450 Volt Elect
C205	Same as C126	
C206	Same as C126	
C207	03000040/3-4	25 µf 50 Volt Elect
C208	03018200	1 x 30 3 x 10 µf Elect
C209	03018040	1 µf 2000 Volt ± 10% Paper
C210	03016360	0.05 µf 2000 Volt Paper
C211	03100510	400 µµf 2000 Volt Mica
C213	03002720/3-272	2.5 µµf 500 Volt ± 5% Ceramic
C216	Same as C142	
C218A&B	03003820	2 x 0.25 µf 600 Volt Paper
C220	03101300	0.022 µf 400 Volt ± 5% Paper
C221	03033350	5100 µµf 500 Volt ± 5% Mica
C222	03030010	1300 µµf 500 Volt ± 5% Mica
C223	03021060	240 µµf 500 Volt ± 5% Mica
C224	03020860	36 µµf 500 Volt ± 5% Mica
C225	03003910/3-391	0.5/0.5 µf 600 Volt Paper
C226	03013740/3-1374	.01 µf 400 Volt Paper
C227	03013740/3-1374	0.01 µf 400 Volt Paper
C228	03029490	2700 µµf 500 Volt ± 10% Mica
C229	Same as C106	
C230	03014510/3-1451	0.1 µf 200 Volt Paper
C231	Same as C126	
C232	Same as C126	
C301	03020430	100 µµf 500 Volt ± 10% Mica
C302	Same as C102	
C303	03030440	4700 µµf 500 Volt Mica
C304	03020430	820 µµf 500 Volt ± 10% Mica
C305	03020470	220 µµf 500 Volt ± 10% Mica
C306	03014530	1.5 µµf 500 V ± 20% Ceramic
C307	Same as C306	
C401	Same as C210	
C501	03003530/3-353	0.5 µf 600 Volt Paper
C502	Same as C501	
C503	03004560/3-456	0.25 µf 2000 Volt ± 10% Paper
C504	03017750	0.5 µf 2000 Volt Paper
C505	Same as C504	
C506	03004570/3-457	0.25 µf 3000 Volt ± 10% Paper
C507	03012470/3-1247	80 µf 475 Volt Elect
C508	03013770/3-1377	15 µf 450 Volt Elect
C509	Same as C507	
C510	03013680/3-1368	4 µf 600 Volt Paper
C511	Same as C126	

FUSES

F501	11001000	3 amp cartridge (slow blow type)
	or	
	11000770/11-1*	1½ amp cartridge
		*For 230 V. operation

INDUCTORS

L101	21006280	2.2 µH
L102	21006510	3.9 µH
L103	21007121	335-900 µH var
L104	21A-4838	variable
L105	Same as L104	
L106	21006101	2.3-5.50 µH var
L107	Same as L106	
L108	21006141	4-8 µH var
L109	Same as L108	
L110	Same as L106	
L111	Same as L106	
L112	21004541	5-11 µH var
L113	Same as L112	
L201	21006151	120-220 µH var
L202	Same as L201	
L203	21A-12822	500-1500 µH var
L301	21006180	4.8 MH
L302	Same as L301	
L501	21000550/21-55	5 H 250 MA
L502	Same as L501	

LAMP

I501	12000840	Lamp, Incandescent, 0.25A

RESISTORS

R101	02040680	6800 ohms ± 5% ½W
R102	02030920	68,000 ohms ± 5% ½W
R103	02041270/2-992	2 megohms ± 5% ½W
R104	02040790/2-1689	20,000 ohms ± 5% ½W
R105	02040550/2-1786	2000 ohms ± 5% ½W
R106	Same as R103	
R107	02031610-12-953	47 ohms ± 10% ½W
R108	02060040/2-1718	200 ohms ± 1% ½W
R109	02060060/2-1719	1800 ohms ± 1% ½W
R110	02060080/2-1720	18,000 ohms ± 1% ½W
R111	02060100/2-1721	180,000 ohms ± 1% ½W
R112	01016620/1-186	200,000 ohms ± 20% ½W var
R113	02041050/2-1679	240,000 ohms ± 5% ½W
R114	Same as R107	
R115	Same as R103	
R116	02030740	12,000 ohms ± 5% ½W
R117	02031040	220,000 ohms ± 5% ½W
R118	02031770	1000 ohms ± 10% ½W
R119	02030450	750 ohms ± 5% ½W
R120	01015150/1-622	500 ohms ± 20% 2W var
R121	02031650	100 ohms ± 10% ½W
R122	Same as R112	
R123	Same as R107	
R124	02031810	2200 ohms ± 10% ½W
R125	02034830	3300 ohms ± 10% 1W
R126	02030400	470 ohms ± 5% ½W
R127	Same as R126	
R129	02031560	18 ohms ± 10% ½W
R130	02030470	910 ohms ± 5% ½W
R131	02032010/2-954	100,000 ohms ± 10% ½W
R132	02031840	3900 ohms ± 10% ½W
R133	01016300/1-581	2000 ohms ± 20% ½W var
R134	02032030	150,000 ohms ±10% ½W
R135	Same as R126	
R136	Same as R126	
R137	01013800/1-161	500,000 ohms ± 20% ½W var
R138	02030910	62,000 ohms ± 5% ½W
R139	02031670	150 ohms ± 10% ½W
R140	02034840	3900 ohms ± 10% 1W
R141	02030410	510 ohms ± 5% ½W
R142	Same as R121	
R143	Same as R141	
R144	Same as R140	
R145	02030930	75,000 ohms ± 5% ½W
R146	Same as R133	
R147	02032040	180,000 ohms ± 10% ½W
R148	02032020	120,000 ohms ± 10% ½W
R149	Same as R137	
R150	02030750	13,000 ohms ± 5% ½W
R151	02031530	10 ohms ± 10% ½W
R152	Same as R151	
R153	Same as R119	
R154	02034770	1000 ohms ± 10% 1W
R155	Same as R119	
R156	02030840	33,000 ohms ± 5% ½W
R157	02030270	130 ohms ± 5% 2W
R158	Same as R156	
R159	02031140	560,000 ohms ± 5% ½W
R160	02030040	15 ohms ± 5% ½W
R161	Same as R160	
R162	Same as R159	
R163	02107830/2-1732	750 ohms ± 5% 10W, W.W.
R164	02036360	330 ohms ± 5% 2W
R165	Same as R164	
R166	Same as R164	
R167	Same as R164	
R168	Same as R164	
R169	Same as R164	
R171	Same as R131	
R172	02032210	4.7 megohms ± 10% ½W
R173	02032050	220,000 ohms ± 10% ½W
R174	01013200/1-453	100,000/100,000 ohms dual var
R175	Same as R172	
R201	Same as R107	
R202	Same as R107	
R203	Same as R107	
R204	Same as R124	
R205	02034850	4700 ohms ± 10% 1W
R206	02032170	2.2 megohms ± 10% ½W
R207	02031940	27,000 ohms ± 10 ½W
R208	Same as R118	
R209	Same as R118	
R210	Same as R124	
R211	Same as R130	
R212	01014220	10,000 ohms ½W var
R213	Same as R107	
R215	02031950	33,000 ohms ±10% ½W
R216	Same as R148	
R217	02031930	22,000 ohms ± 10% ½W
R219	02032240	8.2 megohms ± 10% ½W
R220	Same as R219	
R221	Same as R139	
R222	02035070	330,000 ohms ± 10% 1W
R223	Same as R131	
R224	Same as R219	
R226	Same as R219	
R228	02037870	6800 ohms ± 10% 2W
R229	02034990	68,000 ohms ± 10% 1W
R230	Same as R215	
R231	02034810	2,200 ohms ± 10% 1W
R233	01011090/1-289	200,000 ohms ± 20% ½W var
R234	Same as R228	
R235	Same as R131	
R236	02037020	18,000 ohms ± 10% 2W
R237	Same as R236	
R238	Same as R107	
R239	Same as R134	
R240	01013340	1 meg/1 meg 2W dual var
R241	Same as R228	
R242	Same as R134	
R243	02031900/2-956	12,000 ohms ± 10% ½W
R244	Same as R107	
R245	Same as R107	
R301	02032280	18 meg ohms ± 10% ½W
R302	Same as R173	
R303	Same as R103	
R304	Same as R107	
R305	02034880	8200 ohms ± 10% 1W
R306	02031820	2700 ohms ± 10% ½W
R307	01013840/1-174	10,000 ohms ± 20% ½W var
R308	01030400	10,000 ohms ± 20% ½W var
R309	02031760	820 ohms ± 10% ½W
R311	01026010/1-418	1000 ohms ± 20% ½W var
R312	01030500	10,000 ohms ¼W var
R313	02034180	820,000 ohms ± 5% 1W
R314	02030610	3600 ohms ± 5% ½W
R315	Same as R107	
R316	02030800	22,000 ohms ± 5% ½W
R317	Same as R101	
R318	Same as R316	
R319	02037950	33,000 ohms ± 10% 2W
R320	02037910	15,000 ohms ± 10% 2W
R321	Same as R319	
R322	01014850/1-268	25,000 ohms ± 20% 2W var
R323	Same as R107	
R324	Same as R107	
R401	02032150	1.5 megohm ± 10% ½W
R402	01008770/1-579	50,000 ohms ± 20% ½W var
R403	02036910	62,000 ohms ± 5% 2W
R404	01024240	100,000 ohms ± 20% 2W var
R405	02038010	100,000 ohms ± 10% 2W
R406	Same as R405	
R407	02031900	12,000 ohms ± 10% ½ W
R408	02038000	82,000 ohms ± 10% 2W
R409	02034960	39,000 ohms ± 10% 1W
R410	Same as R206	
R502	Same as R243	
R503	Same as R131	
R504	Same as R112	
R505	02031960	39,000 ohms ± 10% ½W
R506	02036700	8200 ohms ± 5% 2W
R507	02038070	330,000 ohms ± 10% 2W
R508	02035050	220,000 ohms ± 10% 1W
R509	02020100/2-1767	10 megohms ± 1% 2W
R510	02037090	68,000 ohms ± 10% 2W
R511	Same as R510	
R512	02108050/2-10	12,000 ohms ± 5% 10W,WW

SWITCHES

S101	05004201	4P7T Rotary
S102	05004281	3P9T Rotary
S201	05004271	DP3T Rotary
S202	05004261	8P7T Rotary
S301	05004251	3P3T Rotary
S501	05000420/5-42	DPDT Slide
S502	05001130/5-113	SPST Toggle
S503	05000510	SPST Push

TRANSFORMERS

T501	20005192	Plate/Filament

TUBES

V101	25002750	6AH6V
V102	25000020	6AL5
V103	Same as V101	
V104	Same as V101	
V105	Same as V101	
V106	Same as V101	
V107	Same as V101	
V108	25001860	5763
V109	Same as V108	
V201	Same as V101	
V202	25000790	6C4
V204	Same as V101	
V205A,B	25000190	6J6
V206	25001530	12AT7
V207	Same as V202	
V208	25000050	6AU6
V301	25000130	12AU7
V302	Same as V205	
V303	Same as V205	
V401	25003900	5YP11
V501	25000340	6AQ5
V502	Same as V208	
V503	Same as V501	
V504	25000430	OA3/VR75
V505	Same as V102	
V506	25000810	5651
V507	25000490	2X2A
V508	Same as V507	
V509	25000060	5U4G
V510	25000220	5Y3GT
V511	Same as V510	
CR201	26000630	Crystal Unit 1N34

CABLE ASSEMBLY

W501	50015040/46-110	Cable Assembly

MOTOR

B501	81000320	Motor A-C

WARRANTY AND SERVICE NOTICE

for

Industrial Type Cathode-ray Tubes and Instruments

DU MONT INSTRUMENTS

Each instrument manufactured by the Instrument Division of Allen B. Du Mont Laboratories, Inc., is guaranteed to equal or exceed its published performance specifications. It is further guaranteed against defective materials (other than the cathode-ray tube) and workmanship for a period of one year from date of delivery. Any defective instrument or an instrument that does not meet or exceed our specifications will, upon inspection by us, be repaired or replaced at our discretion should such defect appear within the guarantee period.

To register this guarantee, the enclosed guarantee card must be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information is necessary. BOTH THE TYPE NUMBER AND THE SERIAL NUMBER OF THE INSTRUMENT MUST BE GIVEN ON THIS CARD.

Instruments must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

DU MONT CATHODE-RAY TUBES

Industrial type cathode-ray tubes manufactured by Allen B. Du Mont Laboratories, Inc., are guaranteed for 1000 hours of operation or for a six-month period of installation, whichever shall first expire. The right is reserved, however, to limit claims to a period of nine months after shipment from the factory. Adjustments will be made on the merit of each individual claim because of the widely varying applications to which such tubes are subjected, and a tube which becomes defective during the guarantee period will be replaced ONLY AFTER INSPECTION AT THE FACTORY. Cathode-ray tubes which are sent in under the guarantee, must be sent with transportation paid.

BURNED OUT HEATERS AND BROKEN GLASS ARE NOT COVERED BY THE TUBE GUARANTEE

To register a tube guarantee, the guarantee card enclosed with the tube must be properly filled out and mailed to the factory immediately upon receipt of the equipment. Complete information is necessary. TYPE NUMBER AND SERIAL NUMBER OF THE CATHODE-RAY TUBE MUST BE INCLUDED. The serial number of the tube will be found either on the glass stem of the electron-gun structure or on the bulb near the Du Mont brand. Tubes must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time and to furnish merchandise in accordance with current specifications without incurring any liability to modify equipment previously sold, or to supply new equipment in accordance with earlier specifications excepting under the classification of special apparatus.

SERVICE

In order to insure factory service under our guarantees, the guarantee cards enclosed with all instruments and tubes must be properly filled out and returned. In all cases where service or adjustment is requested, please write first to the factory giving complete information concerning the nature of the failure and describing the manner in which the equipment was used when failure occurred. THE TYPE NUMBER AND SERIAL NUMBER of the equipment must also be given. In this way, much time can be saved and unnecessary inconvenience often avoided. When writing in this respect, address:

Allen B. Du Mont Laboratories, Inc.
Instrument Service Department
1500 Main Avenue, Clifton, New Jersey

The Instrument Service Department will then send to the customer, the written procedure for sending the instrument back to the factory. All equipment should be packed and shipped in accordance with this procedure; and identification tags should be attached to each tube or instrument.

REPLACEMENT PARTS

If it is necessary to order a replacement component from the factory, always give the type number and serial number of the instrument and refer to the component by its symbol designation and description on the circuit schematic. This will help to expedite service.

DU MONT

Additional copies of this manual may be secured at a cost of two dollars each or twenty dollars per dozen copies; postpaid in the United States of America only.

Allen B. Du Mont Laboratories, Inc.

Instrument Division

CLIFTON, NEW JERSEY